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EFFECT OF LONG TERM ENDURANCE TRAINING ON
PATIENTS WITH ANGINA PECTORIS AND POST-INFARCTION PATIENTS

by



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A THESIS

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ABSTRACT

The response of twenty-seven angina pectoris patients, AP, and nine post-infarction patients, PI, to eighteen months of endurance training was investigated. Their training was individually directed and adjusted. Treadmills and bicycle ergometers were used. Work loads were selected to elicit a myocardial hypoxic response, at 60 - 70% MVO_2 , for the angina patients and at 70 - 80% MVO_2 for the post infarction patients. The angina group trained five days weekly, while the infarction group trained for three days weekly. All patients were initially tested using a multistage stress test with continuous ECG and blood pressure recording and oxygen consumption measurements. Stress tests were repeated at six month intervals. Both groups increased their fitness levels. Maximum heart rate increased 11% for the angina group and 6.6% for the infarction group. Maximum aerobic power increased approximately 26% for each group. At sub-maximal loads heart rate decreased 10% for the angina group and 13% for the infarct group. Decreases of up to 85% in the ST segment depressions were seen in the angina group for a submaximal load after the training. Duration of the multistage test increased up to 60% and work loads increased up to 75% after the training. The ST segment depression was found to be related to the heart rate. Improvements in this relation were found to occur. This improvement was shown to be paralleled by increases in coronary collateral circulation in the pre and post training coronary angiograms of three subjects. It

was concluded that endurance training can increase the fitness of both angina and post infarction patients. Myocardial fitness was also increased as a result of the training as reflected by the improvement in the ST-HR relationship.

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CHAPTER I

INTRODUCTION

It is paradoxical that the wealthy, overdeveloped nations which have produced so many advances in preventive and curative medicine suffer a greater incidence of heart disease than do the poorer, underdeveloped countries. In Canada, an estimated 2.5 million people have some form of heart disease. 75,000 men die annually in Canada from heart disease and about 90% of these men die from ischaemic heart disease. 40% of the men who die from ischaemic are between the ages of 35 and 52 years, the years when they are highly productive financially. About \$250 million is lost annually either directly or indirectly, as a result of the premature death of these men.(72).

Much of the attention has been focused on the vascular aspects of heart disease, viz. atherosclerosis, cholesterol levels, thromboses etc. This aspect of the disease restricts coronary dilatation, produces narrowing or occlusion of the lumen of the coronary arteries, and hence decreases or stops coronary blood flow, causing diffuse or localized hypoxia or anoxia which can cause arrhythmias, cell necrosis, infarction and death. Most of the research has directed either towards prevention of atherosclerosis by drug and diet manipulation or correction of vascular pathological states by surgical procedures.

However, it is becoming increasingly apparent that the vascular restriction of myocardial oxygen supply is not the only cause of ischaemia but that the disproportion between supply and demand of oxygen produces the ischaemia. Concepts of heart disease are now tending towards a pluricausal production of cardio-pathies (69).

Several investigators, including Raab (58), Von Euler (25), and Bajusz (4) have shown the importance of the role of catecholamines in myocardial metabolism, electrolyte balance, oxygen consumption and the resultant disproportion between myocardial oxygen supply and demand. Longitudinal epidemiologic studies carried out by several groups (42, 53, 74) have shown that cigarette smoking, sedentary living, hypertension, high anxiety-high aggression personalities and diets high in cholesterol and animal fats are important risk factors associated with ischaemic heart disease. Treatment of the disease thus involves treatment of the risk factors as well as the disease itself. Frequent endurance training has been encouraged and the effects of endurance training on post-infarction patients has been studied (22, 40, 61, 30, 70). Some studies have shown the mortality rate of trained cardiac patients to be lower than for untrained cardiac patients (61, 40).

STATEMENT OF THE PROBLEM

This study was carried out to determine the effects of long term endurance training on maximal and sub-maximal measures of heart rate, aerobic power, blood pressure, systolic pressure-heart rate product, pulse oxygen and ST-segment depression and the ST-segment depression-heart rate relationship, ST-HR, in angina pectoris patients and post-infarction patients.

RATIONALE FOR THE STUDY

It has frequently been shown that endurance training causes

relative bradycardia, increases in aerobic power and work capacity, decreased peripheral resistance and other generally beneficial physiologic changes in "normals" (1). The response of "post-infarction" patients to training has been studied and is similar to the response of "normals" (20, 40). Development of coronary collaterals as a result of exercise is still questionable (58). The changes in the ST-segment of the exercise electrocardiogram and the ST-HR relationship in response to exercise have been shown by Detry and Bruce (21), to occur neither in post-infarction patients, nor in angina pectoris patients.

Evidence concerning the long term (18 months) training of angina patients is non-existent. The development of collaterals has not been clearly shown. The ST-HR relationship has been examined in patients who trained for only a few months. This study will attempt to increase the knowledge of the physiological response of angina patients and of "post-infarction" patients to long term training.

CHAPTER II

REVIEW OF THE LITERATURE

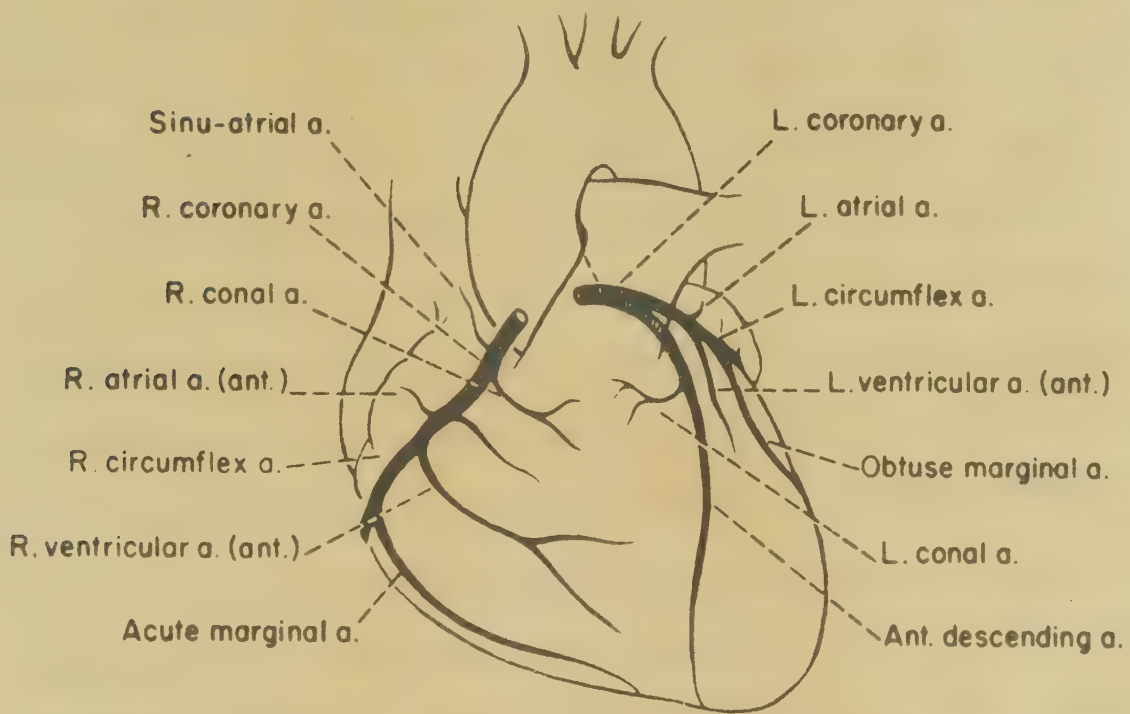
BASIC ANATOMY OF THE HEART

The heart is actually two pumps separated by a septum with the pumps linked in series. The heart requires activation and a supply of fuel to keep it operating properly. The right side of the heart is a low pressure pump in which the right atrium receives the blood from the vena cava, and passes it to the right ventricle which then pumps the blood to the pulmonary circulation. The left side of the heart is a high pressure pump in which the left atrium receives the blood from the pulmonary circulation and passes it to the left ventricle which is the high pressure pump that pumps the blood via the aorta to the systemic circulation. Each side of the heart alternately undergoes contraction (systole), and relaxation (diastole). Activation of the heart begins in the sino-atrial node or pacemaker which is spontaneously excited electrically. The electrical impulse is conducted in a unidirectional path around the heart by a system of highly excitable cells. The fuel is supplied to the heart muscle, the myocardium via the coronary circulation and the metabolic products removed predominantly via the venous side of the coronary circulation. Figures 1 & 2 illustrate diagrams of the chambers of the heart, the excitation system and the coronary circulation.

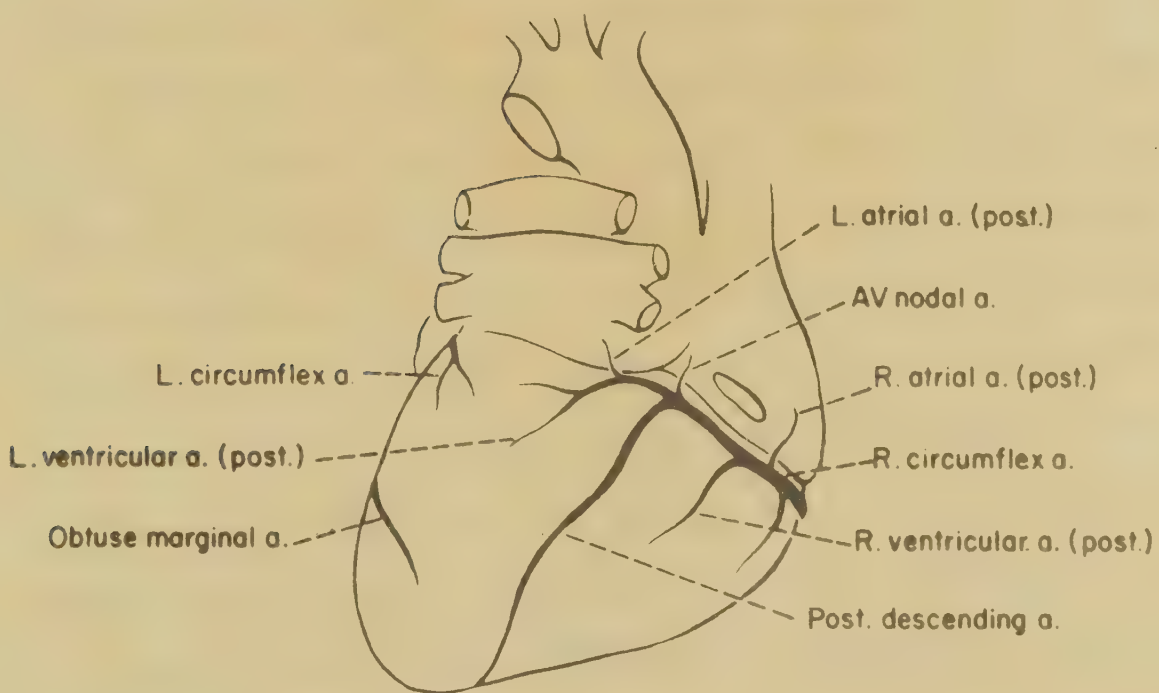
ELECTRICAL CONDUCTION IN THE HEART

The electrical impulse starts in the sino-atrial node, SA

Figure 1.-Balanced Coronary Circulation in the Human Heart



Anterior View



Posterior View

node, located on the posterior aspect of the heart where the superior vena cava joins the right atrium, and passes across the atrium to the atrio-ventricular node, AV node, located on the right side of the inter-atrial septum near the ostium of the coronary sinus. The impulse passes from this node to the ventricles via the bundle of His. The bundle of His passes down the right side of the inter-ventricular septum about 12mm and then divides into the right and left bundle branches, each passing down the corresponding side of the septum. Both branches subdivide after a short distance into the complex network of Purkinje fibres which extends over the subendocardial surfaces of both ventricles. The electrical impulse conducted around the heart is due to the change in the electrical potential across the semipermeable membranes of the myocardial cells. The transmembrane resting potential for atrial and ventricular cells is of the order of 90mV with the inside negative. This is produced by high intracellular potassium ion concentration, low intracellular sodium ion concentration, high extracellular sodium ion concentration and low extracellular potassium concentration. Changes in these relative concentrations either by diffusion of ions across the cell membrane or by gross manipulation of extra cellular or serum electrolyte concentrations produce changes in the transmembrane electrical potential (63). Because of the large differences in transmembrane concentrations of each cation there exists a tendency, a diffusion potential, for the ions to diffuse across the membrane to remove the electrochemical potential gradient. The diffusion potential is related not only to the difference in ion concentrations but also to

the permeability of the membrane for the specific ion and to the changes in permeability and concentration which occur during excitation and relaxation. At rest the membrane is permeable to potassium and impermeable to sodium, thus, the electromotive force is determined by the potassium diffusion potential. With excitation of the cell there is a sharp increase in the permeability of the membrane to sodium exceeding the potassium permeability and causing a Na^+ influx and K^+ efflux and depolarization. Thus, depolarization is dominated by the sodium diffusion potential and the cell membrane becomes positive inside relative to the outside. Repolarization of the membrane occurs with a Na^+ efflux and a K^+ influx. While the depolarization uses the electrochemical gradients, repolarization must occur against these gradients and hence requires an expenditure of energy which is usually derived from oxidative metabolism.

The intrinsic excitation of the pacemaker cells may be due to a small membrane Na^+ conductance which only permits a polarization to -65mV inside not the expected -90mV inside and causes the gradual depolarization of the diastolic membrane potential towards the threshold of activation. Because of this gradual depolarization, the nodal cells activate first and the contraction rate of the heart is determined by the activation rate of the pacemaker.

The gradual depolarization of the pacemaker fibres at rest may be influenced by various factors. Stimulation of the vagus nerve which innervates the SA node causes release of acetylcholine from the nerve endings and produces a slowing of the heart rate. This has been attributed to an increase in K^+ permeability which causes the resting

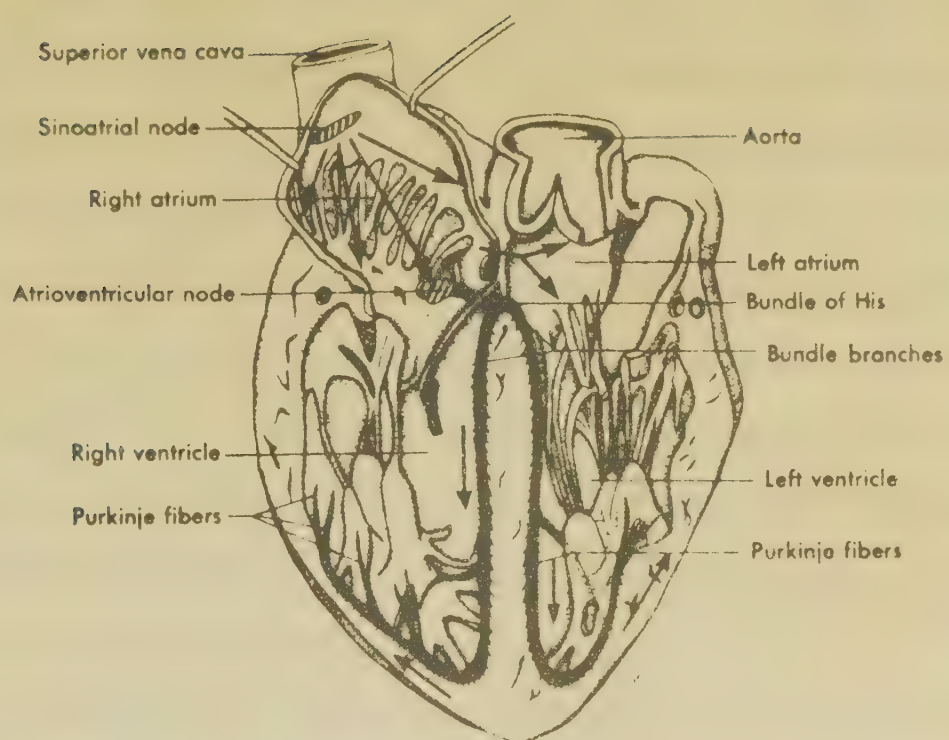


Figure 2. - Schematic drawing of electrical conduction system.

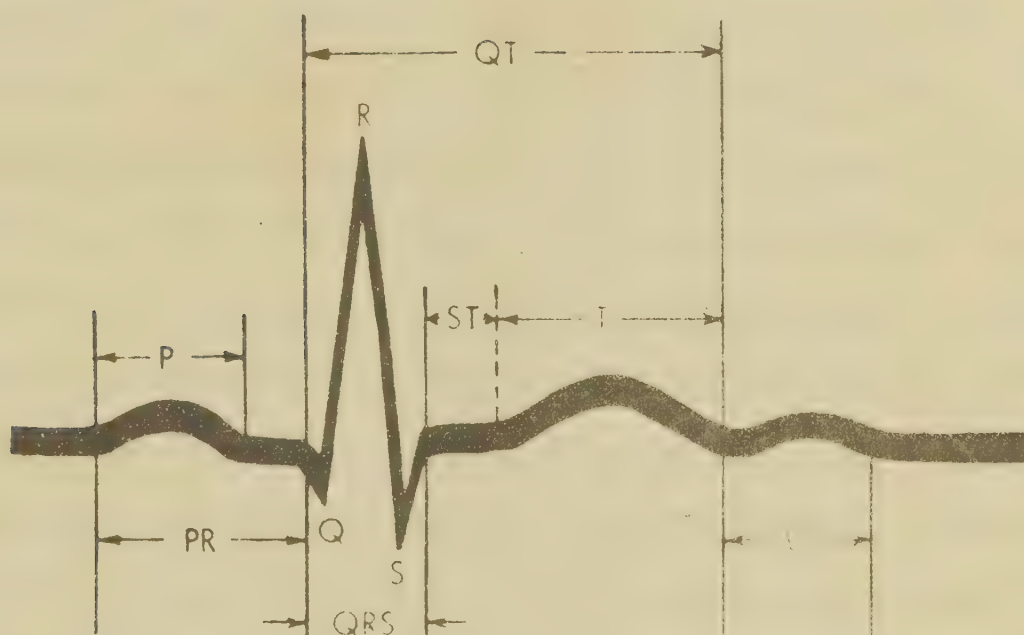


Figure 3. - Normal Electrocardiogram.

diastolic potential to approach the theoretical potassium potential. (64). This would increase the time required for the small Na^+ leak to bring the membrane potential to the threshold of activation level. Conversely, the heart rate is increased by the release of norepinephrine from the sympathetic nerve endings on the SA nodal fibres and by high levels of circulating epinephrine released by the adrenal medulla. This causes the pacemaker to depolarize more rapidly so that threshold is reached more quickly and excitation occurs sooner (64). Detection of the electrical activity of the heart may be accomplished by indirect methods using electrodes on the body surface. This is the basis of electrocardiography.

In 1903 Einthoven first made recordings of the electrical activity of the heart in man which he called electrocardiograms. The interpretations are based on the concept of the vector sum of the movement of ions across the membranes of all cells i.e. the entire myocardium. The presence of positive charge on one side of the membrane and negative charge on the other side creates a dipole with the mid point of the dipole being at zero potential. On depolarization or repolarization the flow of current creates an electrical field in a neighbouring conductor (viz. the body), causing potential differences to exist on either side of the zero line. These potentials can be detected and recorded using electrodes placed at appropriate locations in the electric field. The myocardium depolarizes first in the endocardium and then in the epicardium while repolarization occurs first in the epicardium and then in the endocardium. The normal

electrocardiogram, see fig. 3, consists of a baseline and various deflections or waves. The letters P, Q, R, S, and T are used to designate deflections while the portions between deflections are called segments and the distances between waves are called intervals. The P-wave represents the atrial depolarization, its duration indicates the time required for an impulse to pass from the SA node to the AV node. The PR interval is the time required for a stimulus to pass from the SA node to the ventricles. The QRS complex represents depolarization of the ventricles. The ST-segment is the portion between the end of the complex and the start of the T-wave. It represents the time during which the ventricles remain activated and repolarization may begin. The junction between the complex and the ST-segment is denoted by the letter J. Ventricular repolarization is represented by the T-wave.

MYOCARDIAL HYPOXIA

Myocardial hypoxia, either diffuse or localized, is due to an imbalance either diffuse or regional between the myocardial oxygen demand and the supply of oxygen by the coronary arteries. The oxygen requirements of the heart may be expressed by the equation $O_2 = M + E + P$, in which O_2 is the sum of the specific metabolic processes related to several specific activities of the heart, M, the maintenance cost of keeping the cells alive, E, the oxygen cost of electrical activation and P, the energy required to enable the heart to pump. The maintenance cost is very small but it may be increased by such things as elevated myocardial catecholamine levels. The electrical

cost is also small but can be increased somewhat by increases in heart rate and yet affected little by changes in the inotropic state of the heart. The pumping of the heart has the greatest demand for oxygen consumption.(83). The factors involved in this aspect of the myocardial oxygen consumption are heart rate, wall tension and inotropic state. The measures which correlate best with myocardial oxygen consumption are those which include these three parameters. The product of the heart rate and systolic blood pressure has been reported to be a good, indirect indication of myocardial oxygen consumption (19) and is relatively easy to measure.

The imbalance between myocardial oxygen supply and demand is affected by: 1) a vascular limitation in oxygen supply due primarily to atherogenesis and to functional factors limiting coronary flow, and 2) an exaggeration of the myocardial oxygen consumption caused by a preponderance of catecholamines.

The vascular limitation is imposed by such functional factors as: 1) compression of intramural coronary branches by systolic contraction of the surrounding myocardial fibres; 2) intraventricular hydrostatic compression of sub-endocardial vessels; 3) shortening of the coronary flow facilitating diastole, and 4) constricting neurogenic and pharmacodynamic influences on the coronary arteries as well as structurally induced flow changes caused by atherosclerotic deposits. These limitations due to functional factors usually result in localized areas of ischaemia, especially in the subendocardium, which may cause the spotty focal necrosis which is seen in the ischaemic regions of

autopsied hearts (70,50). Inadequate coronary perfusion pressure gradients, inadequate coronary dilatation and hypermetabolism can augment the effects of the above functional factors. Atherosclerotic limitations of coronary blood supply, although important, have long been overrated in importance in coronary heart disease (58).

However, atherosclerosis does cause narrowing of the coronary arteries which prohibits adequate coronary dilatation and hence causes myocardial hypoxia. Atherosclerosis is still advanced as the cause of infarctions (58). Recently, careful studies have, however, shown an absence of acute thrombotic or atheromatous occlusions in 50% of deaths from infarctions (6,70). This aspect of coronary heart disease is important, but, how important?

The other factor causing the imbalance which results in hypoxia is an excessive metabolic demand for oxygen. A striking feature of the catecholamine-caused elevation of oxygen consumption is the lack of increase in external cardiac work done, thus indicating a highly inefficient use of oxygen. The reasons for this are obscure. It may be due to poor enzymatic manipulation of the oxygen (59) or to an increase in velocity of contraction without parallel increases in tension or in volume output. Excessive catecholamine output can lead to Raab's "breadline concept" (58), that is, the cells near the start of a capillary extract exceedingly large amounts of oxygen, leaving the cells at the tail-end of the capillary with insufficient oxygen available in the blood to meet their demands. This may account for the necrosis frequently found in papillary muscles (10). However,

regardless of how the hypoxia is produced the secondary effect of this hypoxia is important.(58).

EFFECTS OF MYOCARDIAL HYPOXIA

Lack of oxygen supplied to the myocardium causes a decrease in aerobic metabolism and an increase in anaerobic metabolism. This is reflected by a decrease in the aerobic oxidation of free fatty acids and an increase in the anaerobic glycolysis of the myocardial glycogen and of glucose removed from the blood. Thus lactate is released into the coronary venous blood and severe depletion of glycogen can be demonstrated shortly after onset of hypoxia. The shift from aerobic to anaerobic ATP production is mediated by the activation of phosphofructokinase, PFK, and the phosphorylase system. PFK activity is inhibited by the high adenosinetriphosphate, ATP, concentrations normally present in the cell and stimulated by inorganic phosphate and adenosinemonophosphate, AMP, both of which accumulate in the hypoxic heart (84). Thus, during myocardial hypoxia AMP and inorganic phosphate are formed and PFK activity and glycolysis increases. Phosphorylase activity is also increased either by an increase in phosphorylase "a" levels due to catecholamine release or due to an activation of phosphorylase "b" by the increased levels of AMP and inorganic phosphate. There is an increase in glucose uptake thus providing more substrate for hexokinase and hence increasing the production of glucose-6-phosphate. This increase in glycolysis to make up for the loss in energy usually produced by oxidative phosphorylation enables a normal level of ATP to be maintained, however, PC decreases

thus indicating that the glycolysis energy production is inadequate. The glycolysis also decreases the pH thus producing both inadequate energy supply and excessive acidosis. It is because of this acidosis and insufficient energy that changes in electrolyte balance and excitation-contraction coupling occur (84).

The equilibrated rhythmical transmembranous exchange of electrolytes K^+ and Na^+ depends on the energy requiring cation "pump". This "pump" acts during diastole to restore the K^+_i , Mg^+_i and Na^+_o to their normally high levels. During hypoxia, the energy supply for this pump is limited and the required influx of K^+ ions and efflux of Na^+ ions during repolarization are not maintained thus producing the characteristic decrease in internal K^+/Na^+ ratio. The lost K^+ is carried off by the blood.

Decreases in intracellular K^+ and Mg^+ per se, if great enough can cause cellular necrosis. Intracellular potassium is linked to relaxation of actin-myosin complexes, formation of ATP and glycogen storage. Loss of potassium therefore affects each of the above intracellular components negatively. Potassium loss also causes destruction of the cell membrane (4).

The excitation-contraction coupling is also negatively affected by myocardial ischaemia. The interaction between Ca^{++} and the contractile proteins is greatly decreased at acidic pH levels.(84). Thus acidosis due to lactate accumulation during hypoxia may be responsible for the decrease in mechanical performance of the hypoxic heart (84).

These changes may be of significance in myocardial "infarction"

and necrosis but the hypoxia stress in angina at safe levels is probably not great enough to cause cell membrane disruption or defects in excitation-contraction coupling. The ionic "pump" is, however, definitely affected during angina as demonstrated by changes in the ECG.

Myocardial hypoxia is responsible for different abnormalities in the electrocardiogram i.e. arrhythmias, usually due to the electrolyte ratios K^+_i/K^+_o or K^+_i/Na^+_i , becoming less than normal. These changes are caused by an insufficient maintenance of the energy required by the ionic "pump" to establish transmembrane electrolyte concentrations against their electrochemical potential gradients. These changes result in a shortening of the plateau phase of the action potential of the ventricles, a hyperpolarization of the resting potential and thus a depression of the ST-segment.

Different arrhythmias are generally produced by different degrees of local or diffuse electrolyte imbalance. Ectopic beats, beats which originate conduction from an abnormal location in the myocardium, occur as a result of local hyperexcitability in the ventricles due to localized hypoxia and electrolyte imbalance. Thus premature ventricular contractions (PVC) are frequently seen in the hypoxia myocardium, followed, in approximate order of frequency of occurrence, by sinus tachycardia, atrial fibrillation, ventricular tachycardia and fibrillation (58). Further arrhythmias usually do not occur in angina. Before the above arrhythmias occur (isolated PVC's excepted) a depression of the ST-segment is usually seen. This depression is the major diagnostic tool of the exercise ECG. This depression is probably due to a shortening of the phase in which

Na^+ and K^+ fluxes are equal and possibly a decrease in the rate of the rapid repolarization although this may be more significant in the T-wave changes in hypoxia.

PREVENTION OF MYOCARDIAL HYPOXIA

Prevention of myocardial hypoxia must be done by removing or decreasing the effects of the parameters which induce hypoxia viz. the vascular, adrenergic and cardiac work factors which produce either limitations on supply or excessive demands on the supply. The limitations on oxygen supply by the vasculature must be overcome either by reducing the limitations of the existing vasculature or by developing new blood vessels. Reducing the limitations of the existing vasculature can be done by removing constrictions either atherosclerotic or vasomotor. Degeneration of existing atherosclerotic plaques, thrombi, etc. has not been shown to occur. Removing vasoconstriction, i.e. causing vasodilation, by drugs, viz., nitrates, has been shown to decrease the supply-demand imbalance ostensibly by increasing the coronary vasodilatation (50,79) and hence supply (but possibly by increasing peripheral vasodilatation thus decreasing peripheral resistance, cardiac work and myocardial oxygen demand) (50,79). Increases in vascularization have been the target of the many surgical revascularization techniques. When the surgery is successful, the supply-demand imbalance has been shown to diminish. New vascularization, i.e. collaterals or capillaries have been shown in a few cases to develop in animal (23) and in human hearts (⁴⁵39) previously

stressed by hypoxia. This can sometimes occur in angina patients even without any treatment (64). Decreased adrenergic preponderance, either by a decrease of norepinephrine released at the sympathetic nerve endings in the myocardium or by a decrease in epinephrine released by the adrenal glands, and the resultant decrease in oxygen demand is desirable. Emotional stress and tension, tobacco smoking, sedentary living, and physical stress all evoke adrenergic output and hence increase the myocardial oxygen demand. Thus reducing the stress of living by psychological changes, eliminating tobacco smoking, and altering physical activity patterns will alter the daily adrenergic output and thus decrease the myocardial oxygen demand. Decreasing the cardiac work done will also decrease the oxygen consumption. This can be done by decreasing the rate of intramyocardial tension development and the cardiac output, both of which influence myocardial oxygen consumption. These reductions can be accomplished by eliminating all situations which require increased cardiac work or by decreasing the cardiac work needed to cope with a given stress. The first requires that extreme mental and physical limitations be placed on the person's mode of life. The second can be accomplished by redirecting the cardiac output so that a larger proportion of it goes to the stressed organs (i.e. skeletal muscle during exercise) or by decreasing the peripheral resistance to the cardiac output thus decreasing the required rate of myocardial tension development. Since coronary blood flow is greatest during diastole an increase in diastolic time will allow greater flow to occur, more oxygen to be transported and less imbalance between supply and demand. This increase in diastole can result from a slowed

heart rate.

PREVENTION OF EFFECTS OF HYPOXIA

As previously stated the secondary effects of hypoxia creates the most difficulty in the hypoxic heart, hypoxia being only a form of stress. Thus if these secondary effects can be prevented, the effects of hypoxia will be less severe. The effects to be prevented are the pH and electrolyte changes. It is interesting to note that experimental production of lesions is greatly enhanced if preceded by K^+ or Mg^+ deficiencies or Na^+ excesses (4). Conversely if K^+ and Mg^+ are raised and Na^+ decreased prior to treatment with cardiotoxic agents less severe damage occurs (4). Thus dietary manipulation of these electrolytes can often decrease the effects of hypoxia (4). Other sources of K^+ are the endogenous stores of the skeletal muscle and liver (4). Muscular exercise in animals has been demonstrated to produce a large increase in myocardial potassium content and a decrease in myocardial sodium content (4). This effect was of significance for up to 24 hours following the exercise bout. Selye and his co-workers have studied the effects of prestressing with one form of stress on the myocardial response to another stress (69, 70). They have shown that prestressing with exercise cold or restraint will produce resistance to levels of another stress which previously elicited cell necrosis. They have termed this phenomenon "stress induced - stress resistance" (69). The explanation of this phenomenon is still not clearly understood.

Production of electrolyte derangement can be caused by high levels of catecholamines and corticoids. Selye in his work on stress has shown the glucocorticoids to markedly sensitize the myocardium to electrolyte imbalances caused by catecholamine preponderance (69). The glucocorticoid production is augmented during anxiety and smoking but not during muscular exercise (69). Thus electrolyte derangement can be decreased by decreasing corticoid production i.e. by decreasing anxiety and nicotine stress (69,4). The acidosis resulting from myocardial hypoxia can be decreased by increasing the capacity of the myocardium to perform aerobic metabolism. Thus, increases in mitochondria, oxidative enzymes, etc. can decrease acidosis (34). Decreases in serum pH, i.e. acidosis resulting from lactate production due to skeletal muscle anaerobic metabolism can be prevented somewhat by increasing the aerobic power of the body.

PHYSIOLOGICAL RESPONSE TO ENDURANCE TRAINING

Most of the information about endurance training has been derived from short term studies on humans or, for more traumatic observations, from studies on animals. There have been very few longitudinal studies performed on humans. Of particular concern to this study are the longitudinal effect of endurance training on middle-aged subjects both "normals" and "cardiac" patients. Hanson et al. (36) studied the effects of a seven month training program on middle-aged males. Their results show increases in $\dot{V}O_2$ and maximum work capacity of 18% and 22% respectively. Concomitantly, work done/unit sub-maximal heart rate also increased. Resting and exercise cardiac output for a given oxygen uptake declined and produced a relative hypokinesia. This may have been due to a redistribution of the cardiac

output stroke from the viscera and skin to the exercising tissues. Stroke volume increased for moderate and heavy work loads. Hansen et al. also showed that tension-time index, TTI, and ejection time index, ETI, were decreased for submaximal levels while maximum pressure derivative and ventricular ejection rate increased. The findings of this study are supported by similar findings on animals (1) and humans of various ages and levels of fitness (1,24). Thus long term training programs reduce the physical stress on the body per unit work load and increase the maximal stress and work load at which the body can perform. Perhaps more important, in terms of myocardial fitness, training reduces the myocardial oxygen demand as reflected in decreased TTI for a given submaximal load and increase the maximum myocardial oxygen consumption as reflected in an increase in maximal TTI, tension-time index being the best indicator of myocardial oxygen consumption (67).

Apparent from the decreased stress per given load and increased maximal work capacity, physical activity contributes to a decrease in the depletion of the myocardial potassium levels (58,4). In animal experiments, myocardial potassium levels after physical exertion were increased and sodium levels were decreased for up to 48 hours (4). During that time the myocardium was extremely resistant to previously necrotizing levels of fluorocortisol with various stresses, trauma, and nor-epinephrine (4). There have been sporadic case reports of collateral development in exercised men with angina pectoris (29,42). However, collateral development has been noted to be a natural re-

parative process in coronary artery disease and there is a greater prevalence of collaterals in patients with angina than in those without (68). Thus collateral development as a response primarily to physical training has still not been conclusively shown. Physical exercise may induce the development of collaterals. Eckstein (21) showed that exercise induced coronary collateral circulation in dogs with a minimum narrowing of the coronary arteries. However, Kaplinsky et al. (42) failed to show any difference in the coronary arteries of trained and untrained animals.

Training may also affect catecholamine levels in the heart and the adrenal glands and the output of catecholamines in response to physical stress. In rats the norepinephrine content in the heart has been shown to be the same (18) or lower (55) in trained rats than in untrained rats while the epinephrine content in the adrenals is higher in trained rats. The plasma epinephrine levels at rest were lower in exhaustively trained rats than in moderately trained or untrained rats (16). The catecholamine excretion after exercise was lower in trained subjects than in untrained subjects (27).

An antiatherogenic effect of training has not been conclusively demonstrated to occur (58).

RESPONSE OF PATIENTS WITH ISCHAEMIC HEART DISEASE TO TRAINING

Patients with ischaemic heart disease have generally responded to training in the same way that "normals" respond. Hellerstein and his group (39,40) have studied 254 patients for an average of 2.7 years and noted the following results: heart rate and blood

pressure per unit work decreased in response to training while maximum aerobic power increased. Furthermore, ischaemic ST-T changes in the exercise ECG were considerably reduced. Frick and Katila (20) trained seven post-infarction patients (5 with angina) and noted decreases in TTI per unit work load and the characteristic reduced heart rate-increased stroke volume response to physical training. Detry and Bruce (21) studied ST-segment depression of cardiac patients following a 3 month training program. Their results showed a decrease in heart rate and heart rate-blood pressure product and ST-segment depression were greater following training. The relationship of ST-segment depression to heart rate or heart rate pressure product was unchanged. Symptom limited $\dot{MVO}_2$ increased 21% and heart rate-systolic pressure product increased 10% which may indicate an increase in angina threshold. Detry and Bruce concluded that training of coronary patients produced a decreased heart rate-blood pressure product for a given load and that this decrease accounted for the improvement in ST-segment depression per load. Another study from the same lab, Detry et al. (22), showed that an increase in $A-VO_2$ difference occurred in these patients after training. This $A-VO_2$ difference compensated for the bradycardia induced by training. Detry et al. also showed an 8.4% increase in maximum HR for angina patients and a .8% increase for those without angina. They suggested the increased $A-VO_2$ difference was the main factor causing the 22% increase in measured $\dot{MVO}_2$. Aside from the above improvements in myocardial and total body fitness many authors have shown a morbidity

and mortality of up to 30% less in cardiac patients who undergo exercise training than in those who do not exercise regularly (40,61).

CHAPTER III

MATERIALS AND METHODS

Twenty-seven men with angina pectoris, age = (50.6 ± 6.1) and nine men, age = (50.2 ± 7.3) , who had had infarctions but no angina were trained for up to two years. Four of the angina group were hypertensive and eight of the angina group had had infarcts.

The testing and training rooms were maintained at $20^{\circ}\text{C} \pm 2^{\circ}$ and at a relative humidity of $40\% \pm 20\%$. The elevation was 2200 feet above sea level and the atmospheric pressure was 695 ± 10 mmHg.

The initial stress test of the subjects was performed on the referral of the patients by his personal physician. Stress testing of the "post-infarction" patient was also done on referral and no less than six weeks after the most recent infarction. Preliminary screening of the referred patients involved chest x-rays, both antero-posteral and lateral views, twelve lead resting ECG's, SMA12 analysis of blood chemistry (78) and the completion of a questionnaire to determine the medical history of the patient.

The multistage stress test of Bruce (63,13) was used to maximally stress the subject physically and to determine fitness levels. Table I shows the protocol for the stress test, (horizontal lines or dots indicate an observation). ECG, brachial blood pressure and expired air measurements and recordings were made during the stress test. Testing of the subjects including the multistage test and plasma cholesterol and triglyceride levels was repeated at approximately six month intervals.

TABLE I : Multistage Stress Test Protocol

Stages		I	II	III	IV	V	
Speed (mph)		1.7	2.5	3.4	4.2	5.0	
Elevation (%)		10	12	14	16	18	
Expired Air (time of collection)		—	—	—	—	—	
ECG (time of recording)	•	•	•	•	•	•	•
Blood Pressure (time of recording)	•	•	•	•	•	•	
ECG (time of monitoring)	—	—	—	—	—	—	—
Time (min)		0	3	6	9	12	15
	Rest Period	Exercise Period				Recovery Period	

Electrocardiograms were continually monitored using a Tektronic oscilloscope and recorded for 10 seconds every 30 seconds starting before the test and continuing until no ischaemic changes in the ECG were evident after the test. The electrodes for the ECG were placed as follows: reference lead at the apex of the heart, the exploratory lead at the V₅ right position and the ground lead on the manubrium. Brachial blood pressure was measured sphygmomanometrically at rest and at

1 minute intervals during the test and 1 minute after the test.

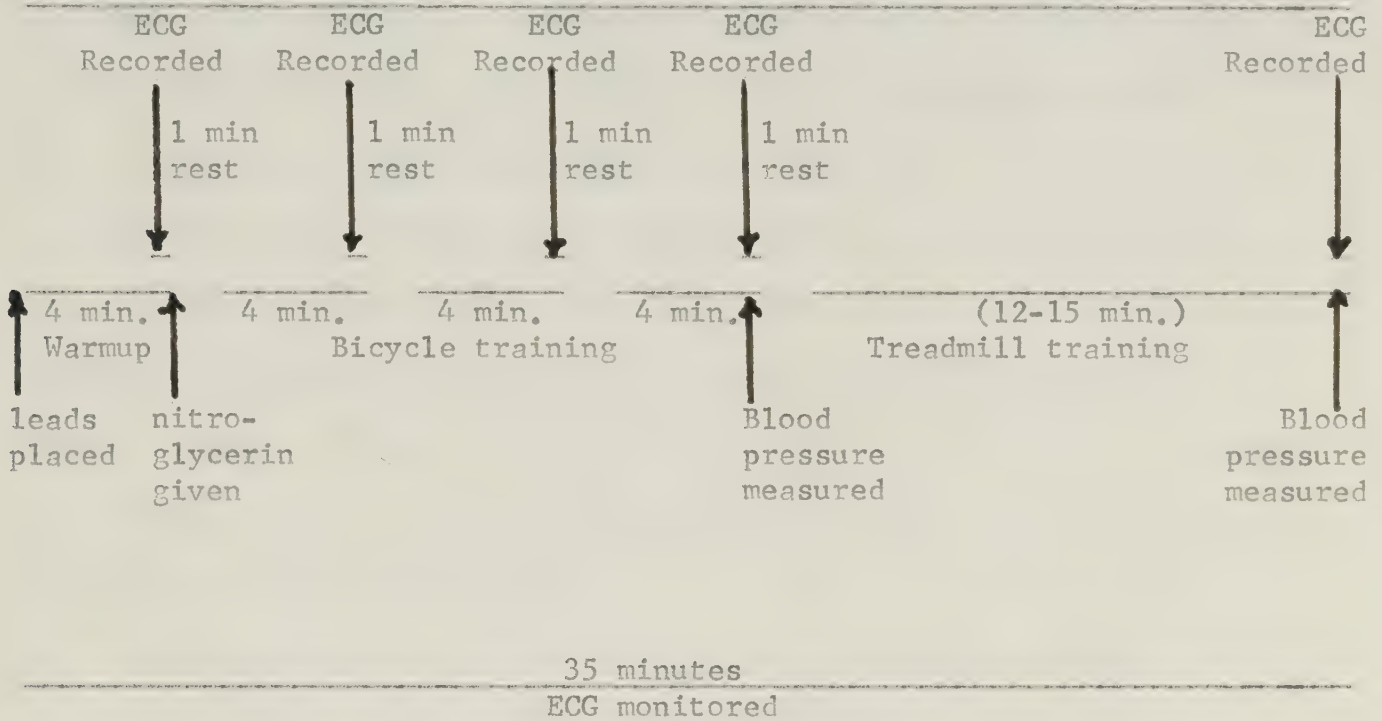
Expired air for gas analysis was collected during the third minute of each stage and when possible during the final minute of the test.

The test was terminated immediately when more than two consecutive extra systolic ventricular contractions were detected, i.e. possible paroxysmal tachycardia not bigeminy, or when signs of general circulatory collapse were noted, viz. pallor, sweating and especially a fall in systolic blood pressure and possibly pulse rate. Severe angina and ST-segment depression were not by themselves sufficient criteria for stopping the test.

Expired air was collected in meteorological balloons via a low resistance Collins triple "J" valve and flexible tubing (1½" i.d.). The oxygen and carbon dioxide content in the expired air was analyzed immediately after collection using a Beckman E2 paramagnetic oxygen analyzer and a Godart Capnograph infra red CO₂ analyzer. The gas analyzers were calibrated immediately prior to and following the gas collection using accurately calibrated test gases. Inspired volumes were measured and corrected to STPD using the appropriate temperature, humidity and pressure correction factors. The inspired volume was continually recorded via a DC potentiometer signal output of volumeter measurements on a Hewlett Packard 7128A recorder.

The patients trained using Quinton treadmills and Monark bicycle ergometers. Figure IV shows the protocol of a training session. The ECG's were continually monitored by nurses, trained in the intensive care of cardiac patients, using oscilloscopes. ECG recordings

FIGURE 4 Protocol of a Training Session



of 10 seconds duration were made during every phase of every training session on every patient. Brachial blood pressure was measured immediately following the treadmill phase or the third bike phase of a training session at least one time per week. Any subjective feelings of angina, dizziness etc. were noted. Changes in training loads were made whenever the current load did not provoke a mild discomfort (load was increased), or when the load provoked extreme discomfort (load was decreased). Training loads were thus designed to place a hypoxic, yet safe, stress on the myocardium during each training session. Nitroglycerin, either 1/100mg, or 1/200mg, was given to those patients on whom it was effective. This allowed

higher training loads to be performed for a given level of myocardial hypoxia. Thus a greater gross training stress could be imposed per unit myocardial stress. The training load on the bicycle ergometer was changed by at least 75Kgm/min whenever a change was made. The training on the treadmill was changed by first increasing the speed of walking until the patient could walk comfortably at about 4.0 mph whereupon, increases in training load were made by increasing the grade up which the patient had to walk. When the grade was too great, about 12%, skillful walking became difficult and the grade was lowered and the speed increased.

During the course of the study, there were slight changes in protocol of the maximum stress test with expired air collection. Initially the exercise blood pressure was not measured. Thus the blood pressure, systolic blood-pressure-heart rate product, BP X HR, and observations for the initial multistage tests were not available. The CO₂ content in the expired air was not measured during the initial multistage tests. This resulted in an absence of R.Q. observations for the initial stress tests. The $\dot{V}O_2$, $\dot{V}O_2/Kg$ and pulse oxygen measurements taken at that time were later corrected to account for the lack of expired CO₂ in the measurements. This was done by calculating the oxygen consumption in later tests both with and without expired CO₂ using the following equation:

$$\dot{V}O_2 = \frac{\text{Volume X collection time (sec.) X Patm} - \frac{PH_2O}{760} \text{ X } \frac{273}{273 + T^{\circ}C} \text{ X (100 - \%O}_2 - \%CO_2) \cdot 265 - \%O_2}{60}$$

The ratio, $\dot{V}O_2$ with CO_2 / $\dot{V}O_2$ without CO_2 , was then obtained for each measure. The ratio obtained at the heart rate which corresponded to the heart rate of a $\dot{V}O_2$ measurement of the initial test, was then used to correct the $\dot{V}O_2$ without CO_2 of the initial test to a $\dot{V}O_2$ with CO_2 measurement. Evaluation of this procedure was performed by using the ratio obtained in test three to correct the corresponding $\dot{V}O_2$ with CO_2 measure and then comparing it with the actual $\dot{V}O_2$ with CO_2 value obtained during test two. This resulted in less than $\pm 2\%$ error, in the $\dot{V}O_2$ measure. This correction of scores was performed on the measures of nineteen of the thirty-six subjects. The improvement in $\dot{V}O_2$ from test 1 to test 2 on these nineteen subjects was equivalent to the improvement in $\dot{V}O_2$ from test 1 to test 2 for the other seventeen subjects. The results could therefore be grouped.

SMA-12 analyses were carried out by a commercial laboratory on a Technicon Instruments SMA12-60. The methods for each analysis are standard for the particular model used. The screening analyses were performed using this autoanalyzer which measures albumin, alkaline phosphatase, blood urea nitrogen, calcium, cholesterol, glucose, inorganic phosphorous, lactic dehydrogenase, serum glutamic oxalacetic transaminase, total bilirubin, total protein, and uric acid. The triglyceride and cholesterol analyses (73,47) were also performed in the same laboratory on single channel (Technicon) autoanalyzers.

The coronary angiograms were performed using the technique developed by Sones

The ST-depression was measured by averaging the depression of

10 - 15 consecutive beats. Upward sloping ST-segments were not used in this measurement, nor were beats used that showed a predominately J-junction depression. The ST-depression is that distance (in mV, paper calibrated $1\text{mm} = 1\text{mV}$) from the zero potential line (P-R interval) to the part of the ST-segment 50 - 69 msec. after the nadir of the S wave. Only horizontal or downward sloping ST-segments were measured. Measurements were taken by one cardiologist over a 4 hour period with frequent random checks on measurements.

CHAPTER IV

RESULTS

The general description of the subjects is shown in Table II. They are quite closely matched for age and the change in weight over the training period was negligible.

TABLE II Description of Subjects

	Angina	Post Infarction
Age (yrs)	50.6 $\pm$ 6.1	50.2 $\pm$ 7.3
Weight (lbs)	165 $\pm$ 7.5	160 $\pm$ 6.4
Change in weight (lbs)	1.0 $\pm$ 1.2	1.3 $\pm$ 3.8

The subjects served as their own controls with the means of the measures at the 6 month, 12 month and 18 month intervals compared to the means of the initial measures to determine changes resulting from the training.

The results of the repeated maximal stress tests over a 12 month period for the angina group, AP, are shown in Table III. The following are the important observations in Table III:

- (1) The duration of the test significantly increased over the first six months and continued to increase slowly ($p > .05$) for the next six months.

TABLE III Stress Test: Maximal Values For Angina Patients

Variable	Test # (6 month intervals)			Significantly Different Means (p .05)
	1	2	3	
Duration (sec.)	327	488	511	1-2, 1-3
Heart Rate (beats/min)	137	143	151	1-2, 1-3, 2-3
Systolic Blood Pressure (mm Hg.)	172	170	175	n.s.
Pressure X Rate Product (/100)	262	271	287	1-2, 1-3, 2-3
S-T Segment Depression (mV)	2.7	2.0	1.7	1-3
$\dot{V}O_2$ (symptom limited) (L/min)	1.425	1.750	1.800	1-2, 1-3
$\dot{V}O_2$ /Weight (ml/Kg)	18.73	22.11	22.91	1-2, 1-3
Pulse Oxygen (ml.O ₂ /beat)	0.149	0.162	0.166	1-2, 1-3
Respiratory Quotient	1.04	.98	1.07	n.s.

- (2) The maximum measured heart rate increased significantly over the entire one year period. This amounted to an 11% increase.
- (3) The maximum systolic blood pressure-heart rate product, BP X HR increased significantly over the one year. This amounted to a 9% increase.
- (4) $\dot{V}O_2$, $\dot{V}O_2$ /kg body weight and oxygen pulse increased significantly over the first six months and continued to

TABLE IV Stress Test: Maximal Values for "Post Infarction" Patients

Variable	Test # (6 month intervals)				Significantly Different Means (p .05)
	1	2	3	4	
Duration (sec.)	468	603	646	695	1-2, 1-3, 1-4
Heart Rate (beats/min)	152	153	159	162	n.s.
Systolic Blood Pressure (mm Hg.)	186	180	174	169	n.s.
Pressure X Rate Product (/100)	294	278	317	310	n.s.
$\dot{M}VO_2$ (symptom limited) (L/min)	1.81	2.02	2.09	2.31	1-3, 1-4, 2-3, 2-4
$\dot{M}VO_2$ /Weight (ml/Kg/min)	24.8	26.8	29.3	30.9	1-3, 1-4 2-3, 2-4
Pulse Oxygen (ml. O_2 /beat)	.158	.189	.187	.193	n.s.
Respiratory Quotient	Sample size - too small				--

increase slowly ($p > .05$) over the next six months. The yearly

increases were 26%, 26% and 8% respectively.

The results of the multistage stress test at maximum for the "post-infarction" group are shown in Table IV. The following are the important observations in Table IV:

- (1) The duration of the multistage test increased significantly over the first six months and steadily thereafter. Increases in the first, second and third six month periods were 25%, 7.5% and 7.4% respectively.
- (2) Heart rate increased 6.6% over the 18 months.

FIGURE 5: Changes in Maximal Values for Angina and Post-Infarction Patients

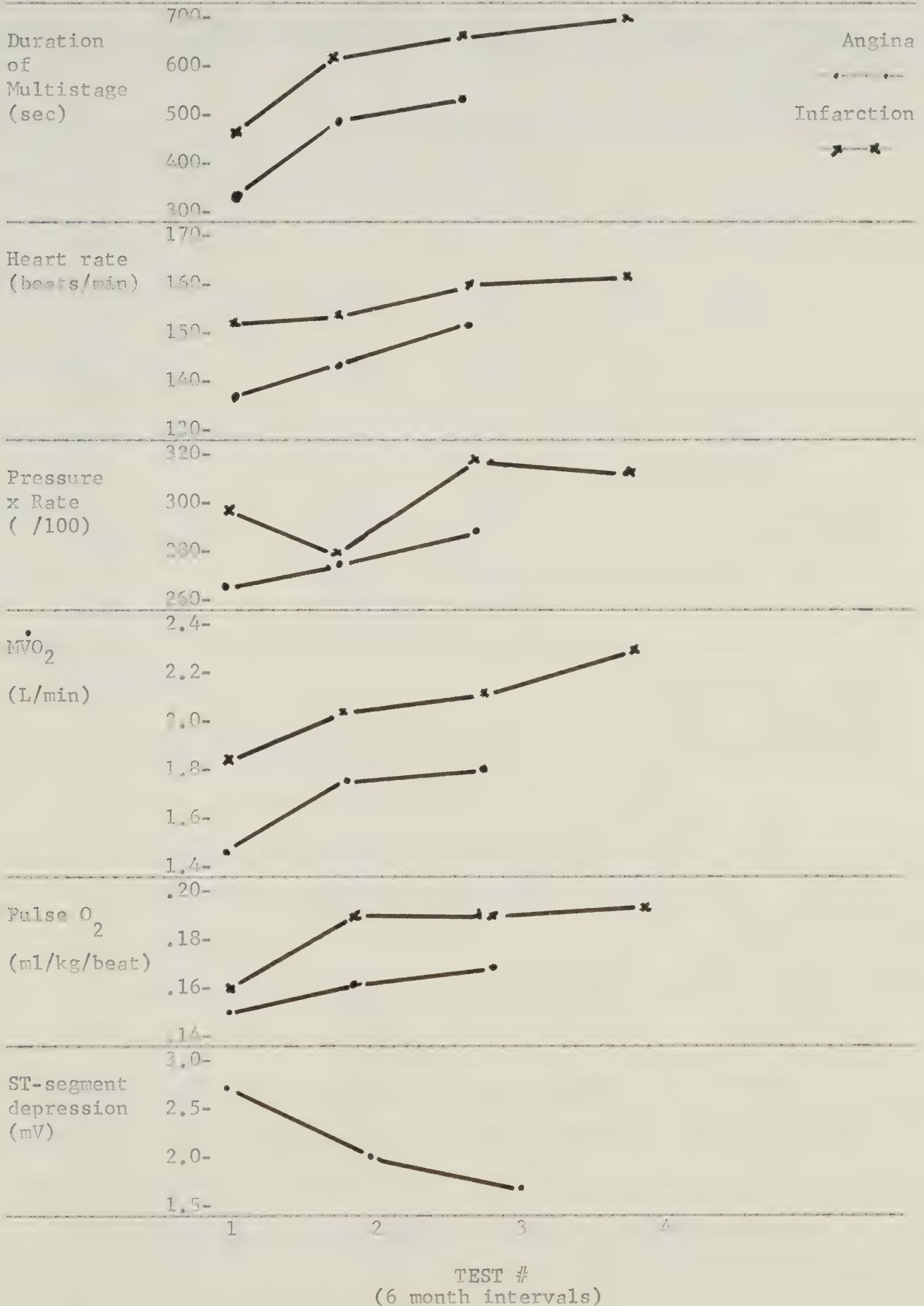


TABLE V Stress Test: Submaximal Values in Stage I For Angina Patients

Variable	Test # (6 month intervals)			Significantly Different Means (p. 05)
	1	2	3	
Stage I of Multistage test				
Heart Rate (beats/min)	113	105	103	1-2, 1-3
Systolic Blood Pressure (mm Hg.)	143	136	138	n.s.
Pressure X Rate (/100)	269	235	241	n.s.
S-T Segment Depression (mV)	9.6	3.6	2.2	1-2, 1-3, 2-3
$\dot{V}O_2$ (L/min)	1.10	.95	1.03	1-2
$\dot{V}O_2$ /Kg (ml/Kg/min)	14.1	12.9	13.7	1-2
Pulse Oxygen (ml.O ₂ /beat)	.130	.133	.140	1-3

(3) Blood pressure decreased 8% over the 18 months.

(4) Pressure-rate product increased 6% over the 18 months.

(5) $\dot{V}O_2$, $\dot{V}O_2$ /kg and pulse O₂ increased 25%, 25% and 71% respectively.

(6) ST-depression is not consistently evident in "PI" patients and hence not shown here.

The results of the exercise of angina patients at submaximal levels during the multistage test are shown in Table V. The following observations are noteworthy:

(1) Heart rate decreased 10% (statistically significant) over

TABLE VI Stress Test: Submaximal Values in Stages I & II For "Post-Infarction" Patients

Variable	Test # (6 month intervals)				Significantly Different Means (p .05)
	1	2	3	4	
Stage I of Multistage test					
Heart Rate (beats/min)	106	94	94	96	n.s.
Systolic Blood Pressure (mm Hg.)		149	145	142	n.s.
Pressure X Rate Product (/100)		145	145	136	n.s.
$\dot{V}O_2$ (L/min)	1.10	0.95	0.77	0.85	n.s.
$\dot{V}O_2$ /Kg (ml/Kg/min)	15.0	13.8	13.2	12.7	n.s.
Pulse Oxygen (ml.O ₂ /beat)	.142	.145	.148	.137	n.s.
Stage II of Multistage test					
	1	2	3	4	
Heart Rate (beats/min)	129	119	114	112	1-2, 1-3, 1-4
Systolic Blood Pressure (mm Hg.)		157	154	148	n.s.
Pressure X Rate Product (/100)		194	184	180	n.s.
$\dot{V}O_2$ (L/min)	1.53	1.47	1.36	1.44	1-2, 1-3, 1-4
$\dot{V}O_2$ /Kg (ml/Kg/min)	20.8	19.6	18.4	18.7	1-2, 1-3, 1-4
Pulse Oxygen (ml.O ₂ /beat)	.165	.161	.157	.161	n.s.

FIGURE 6: Submaximal values for Angina Patients (Stage I) and Post-Infarction patients (Stage II)

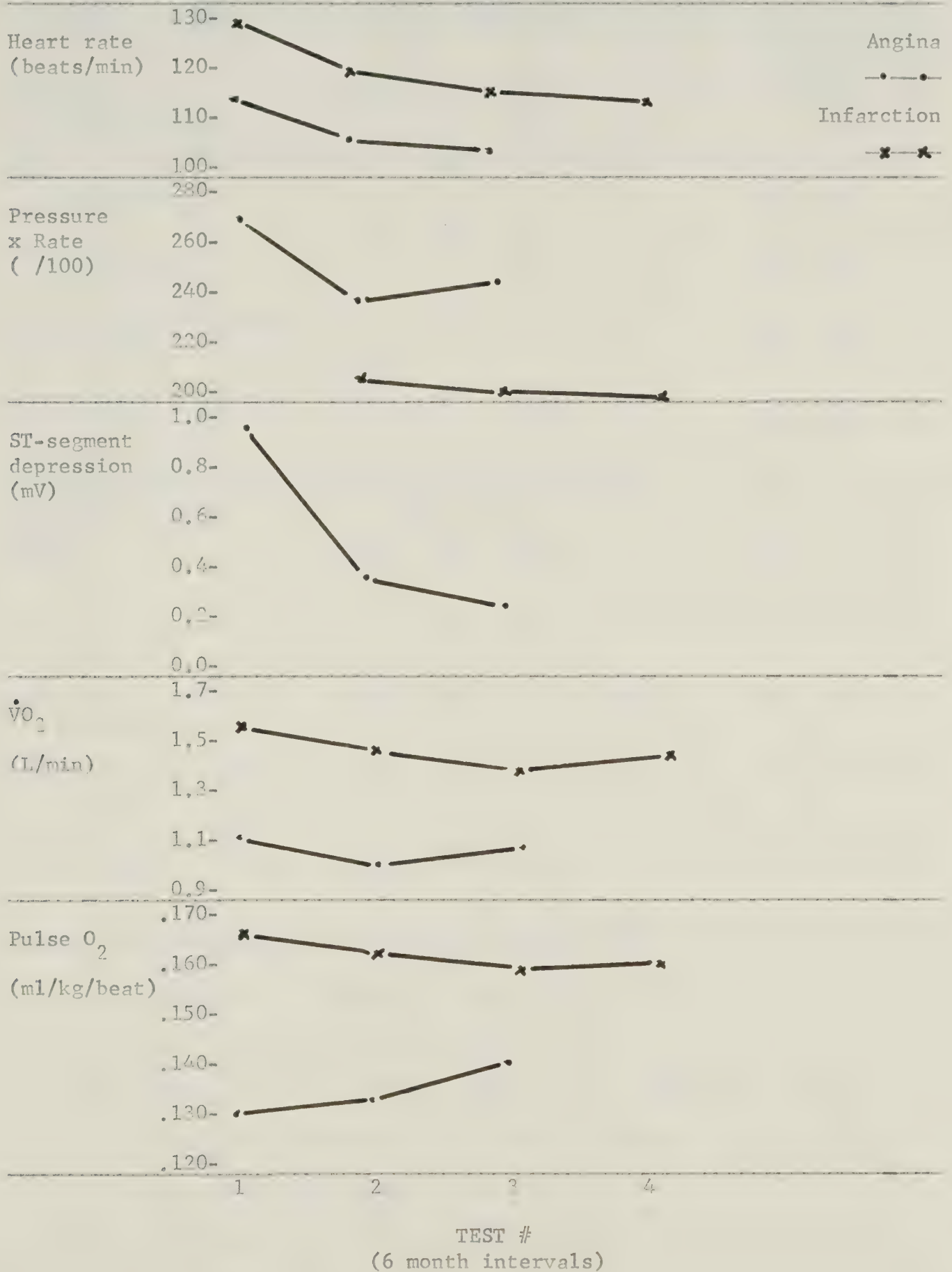


TABLE VII Daily Training Stress - Angina Patients

Variable	Time (in months)				Significantly Different Means (p .05)
	0	6	12	18	
BICYCLE ERGOMETER					
Load (Kpm/min)	396	529	641	671	1-2, 1-3, 1-4, 2-3, 2-4
Heart Rate (beats/min)	112	118	119	124	1-2, 1-3, 1-4, 2-4, 3-4
Systolic Blood Pressure (mm Hg.)	125	126	127	132	1-2, 1-3, 1-4, 2-4, 3-4
Pressure-Rate Product (/100)	145	150	151	165	1-2, 1-3, 1-4, 2-4, 3-4
TREADMILL					
Speed (mph)	3.1	3.6	3.8	4.1	1-2, 1-3, 1-4, 2-3, 2-4, 3-4
Elevation (%)	0	4.6	4.9	4.2	1-2, 1-3, 1-4
Heart Rate (beats/min)	108	115	117	117	1-2, 1-3, 1-4
Systolic Blood Pressure (mm Hg.)	121	127	127	126	1-2, 1-3, 1-4
Pressure-Rate Product (/100)	132	148	149	142	1-2, 1-3, 1-4

the first six months and then changed slightly over the next six months. (Stage I decreased 2%).

(2) Blood pressure decreased slightly (not significant) in the first six months (Stage I - 5%) and remained decreased after the second six months.

(3) Pressure-rate product decreased 10% (not significantly) in Stage I.

TABLE VIII Daily Training Stress "Post Infarction" Patients

Variable	Time (in months)				Significantly Different Means (p .05)
	0	6	12	18	
Bicycle Ergometer Load (Kpm/min)	525	658	817	848	1-2, 1-3, 1-4, 2-3, 2-4
Heart Rate (beats/min)	118	117	127	129	1-3, 1-4, 2-3, 2-4
Systolic Blood Pressure (mm Hg.)	132	126	130	131	n.s.
Pressure X Rate Product (/100)	156	150	166	171	2-3, 2-4
Treadmill Speed (mph)	3.7	3.8	4.2	4.3	1-3, 1-4, 2-3, 2-4
Elevation (%)	0	4.1	4.9	3.9	1-2, 1-3, 1-4, 2-3
Heart Rate (beats/min)	117	118	123	124	1-3, 1-4, 2-3, 2-4
Systolic Blood Pressure (mm Hg.)	127	124	129	129	n.s.
Pressure X Rate Product (/100)	150	149	158	159	n.s.

(4) ST-segment depression decreased (significantly) 85% in Stage I.

(5) VO_2 and VO_2/kg decreased (significantly) in the first six months in Stage I (13%). In the next six months, further decreases were shown in Stage I (2%).

(6) Pulse oxygen increased (significantly) over the 12 month period.

FIGURE 7: Daily training stress on Bicycle Ergometers for Angina and "Post-Infarction" Patients

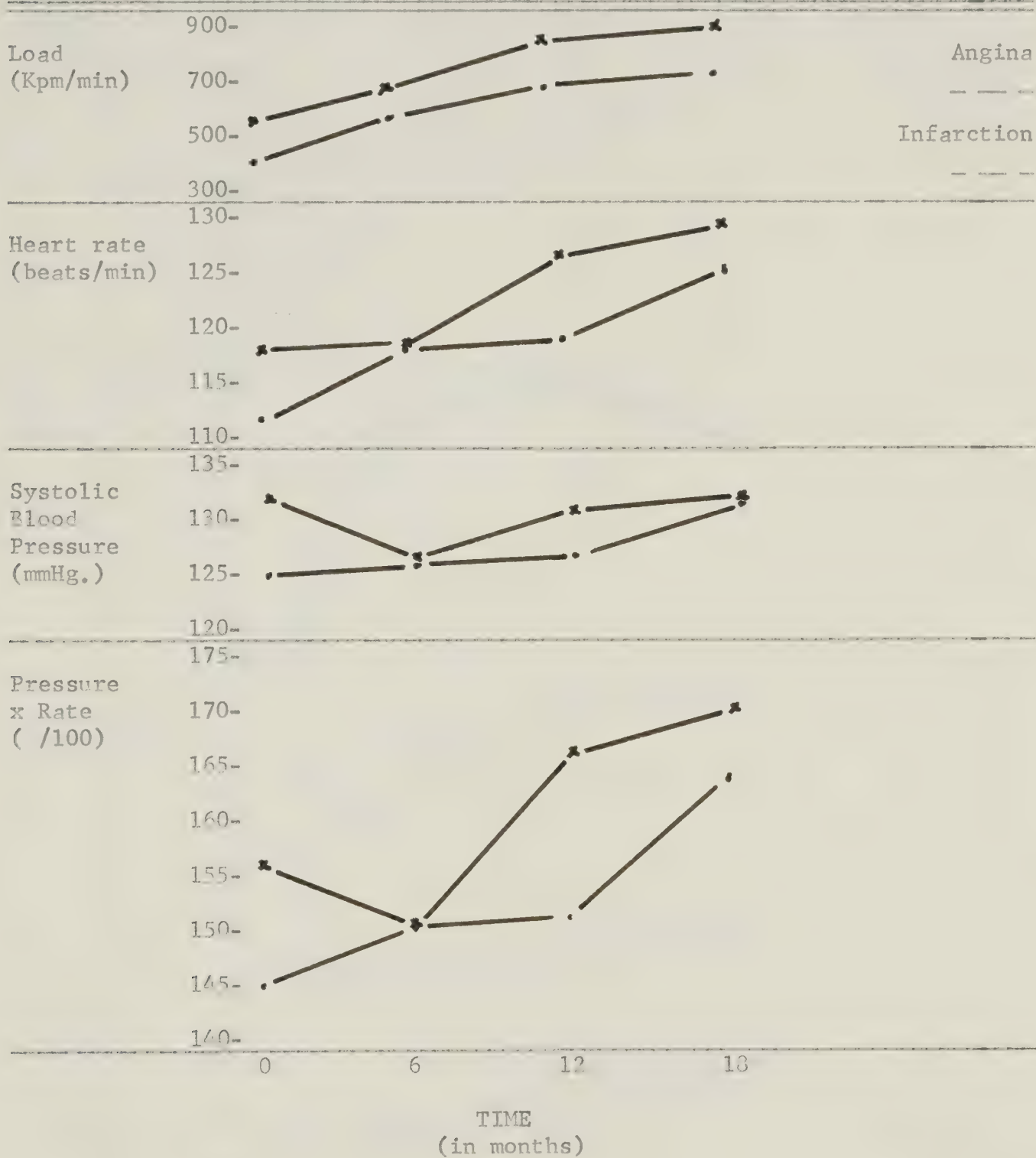


FIGURE 8: Daily training stress on Treadmills for Angina and Post-Infarction Patients



TABLE IX Plasma Cholesterol and Triglycerides - Angina and Post-Infarction Patients

	Time (in months)				Significantly Different Means (p .05)
	0	6	12	18	
Angina Patients					
Cholesterol (mg%)	252	267	251	235	n.s.
Triglycerides (mg%)	166	150	135	145	1-3
Post-Infarction Patients					
Cholesterol (mg%)	224	245	252	234	n.s.
Triglycerides (mg%)	112	108	107	105	n.s.

The results of the "post-infarction" patients at submaximal loads during the multistage test are shown in Table VI. The following results are noteworthy:

- (1) Heart rate decreased 8% in Stage I and 13% in Stage II over the 18 months. Decreases were in the first six months in Stage I and continuous over the 18 months in Stage II.
- (2) Blood pressure decreased 6% in Stage I and in Stage II continuously over the 6-18 month period.
- (3) Pressure-rate product decreased 7% in Stage I and in Stage II continuously over the 6-18 month period.
- (4) $\dot{V}O_2$ and $\dot{V}O_2/kg$ decreased 20% over the first 12 months in Stage II. Increases of 8% occurred in the 12-18 month period.

- (5) Pulse oxygen did not change significantly over the eighteen months.

The changes in training loads, heart rate, blood pressure and pressure-rate product for the angina patients are shown in Table VII. The following results are noteworthy:

- (1) Training loads increase steadily over the 18 months (75% increase).
- (2) Training heart rate increased 10% over 18 months.
- (3) Training pressure-rate product increased 14% on the bike and 8% on the treadmill.

The changes in training loads, heart rate, blood pressure and pressure-rate product for the "PI" patients are shown in Table VIII. The following results are noteworthy:

- (1) Training loads increased 60% over the 18 months.
- (2) Training heart rate increased 8%, training systolic blood pressure changed little and the pressure-rate product increased 8% over the 18 months.

The changes in the plasma cholesterol and triglyceride levels for both the angina and "PI" patients are shown in Table IX. The changes were irregular and non-significant.

There were also some interesting qualitative observations on the subjects.

- (1) The number of nitroglycerin tablets taken by the angina patients during their regular daily activity decreased from 7 per week at the onset of the study to 1 per week after 12 months.

- (2) The "walk through" phenomenon (51,45) was frequently observed. That is, the patient while exercising at a certain intensity which provokes angina, can continue to exercise without stopping or slowing and the angina will subside. Kattus (45) has shown this "walk through" to be accompanied by a decrease in heart rate and a decrease in blood pressure. He attributed the "walk through" to a decrease in peripheral resistance caused by a vasodilatation in the skeletal muscles. Furthermore, a few patients tolerated their training load more if their warmup load is higher. Some patients walked through their angina frequently while others never did. This only occurred at submaximal work loads.
- (3) Many patients consistently had arrhythmias of one type or other during their training bout. The typical arrhythmia pattern of a particular patient was seldom cause for concern since all other indications of difficulty were absent. Thus some patients frequently (almost daily) had ventricular extrasystolic contractions or chest pain without it being problematic. However, if a patient displayed an atypical arrhythmic pattern it was often accompanied by other negative indicators and was indeed cause for concern. For example, if a man normally had chest pain but never had ventricular extrasystoles,

he immediately brought on increased attention by the nurses (covert) and frequently had his exercise stopped. Conversely, a patient who frequently had extrasystoles and no chest pain would evoke concern if chest pain occurred. This aspect of the training of angina patients further emphasized the great interindividual variability in angina patients.

The patients all expressed subjective improvement in their daily life and many returned to a more active life style.

The intraindividual ST-segment depression correlated very highly with heart rate ($r=.87$, $p < .05$). The interindividual correlation between maximum heart rate and maximum ST-segment depression was quite low ($r=.387$, $p > .05$). This further shows the interindividual variability in the angina patients. The intraindividual ST-HR relationship, although high, is neither a linear function nor a mathematically describable function. The changes in the ST-HR relationship did not occur in a predictable fashion from one subject to another. It would be very difficult to develop a mathematical function for this relationship and the improvement in this relationship and hence be difficult to quantitatively relate the relationship and the improvement to the scores of a population. For this reason the changes in ST-HR relationship were measured subjectively and given a score on a scale from -7 - +7 based on the individual's ST-HR improvement relative to that of the sample in this study. Improvement was given a positive score while regression was given a negative score. The subjective measure was based on the heart rate at which ST-depression

began and on the approximate slopes of the ST-HR relationship. An improvement in ST-HR relationship is a decrease in ST-segment depression/unit heart rate or an increase in heart rate required to evoke an ST-segment depression. Changes of up to 86% were seen in the post training ST-HR relation relative to the initial levels. That is, the ST depression for a given heart rate decreased 86% in some patients. Increases of 30 beats/min in the heart rate required to evoke an ST depression were observed in some patients. These were the largest improvements. Most of the results showed approximately a 60% decrease in ST depression per unit heart rate and an 8 beat/min increase in the minimum heart rate at which ST-segment depression occurred.

The correlation matrix is included in the Appendix. Noteworthy correlations are included in their appropriate places in the discussion of the results.

CHAPTER V

DISCUSSION

One primary objective of the endurance training is to increase the efficiency of the cardio-respiratory system so that following training the same stress to the body or the same work can be accomplished with less stress imposed upon the individual. The other primary objective is to increase myocardial functional capacity so that a greater work load or greater stress on the myocardium can be tolerated by the individual.

The increase in maximal heart rate which occurred reflects an increase in myocardial functional capacity. The maximal heart rate increased 11% for the AP group. Detry and Bruce (21) found an increase in maximal heart rate of 8.4% after three months of training. The maximal heart rate of the PI patients did not increase initially, however during the 6 - 18 month interval an increase in maximal heart rate of 6.6% did occur. Detry and Bruce (21) did not find an increase in maximal heart rate for PI patients, but their study was only for a three month period. The increase in maximal heart rate for the AP group in this study was significantly related ($r = .62$) to the improvement in the ST-segment-heart rate relationship. Detry and Bruce did not find a change in the ST-HR relationship in their patients. Bruce et al. (12) did find an improvement in the ST-HR relationship in another study on eight "asymptomatic" healthy men trained for eight weeks. The heart rate for a given submaximal load decreased 10% for the AP group and 13% for the PI group. In the

Detry and Bruce study the decrease was 9% for their combined group. Hanson et al. (36) found a 13% decrease in heart rate for a submaximal load in their middle-aged normal subjects. Thus the heart rate response at submaximal loads in the AP and PI groups is similar to but slightly less than the response for middle-aged normals. This may be due to a lower absolute training stress in this study or due to differences between the response of the patients and the normals to training.

The duration of the multistage test increased for both the AP and PI groups. This may be due in part to the decrease in heart rate/unit work load that would enable the patient to walk the duration of the previous test at a submaximal heart rate thus enabling him to reach a higher work load in the multistage test by continuing until maximal heart rate was reached. The increase in maximum heart rate that occurred in both groups would also allow an increase in the duration of the test.

The maximal aerobic power increased in both the AP and PI groups. Other authors have also shown aerobic power to increase in cardiac patients (39,40,32). In the AP group, as Detry and Bruce have pointed out, the maximal aerobic power is a maximal measured or symptom limited aerobic power with the end of the test determined by hemodynamic dysbalance and not by the plateauing of $\dot{V}O_2$ as is the usual determinant in normals and "post-infarction" patients. Thus increases in $\dot{M}VO_2$ are caused to a large extent by increases in myocardial efficiency rather than total body fitness. The increase in myocardial efficiency will determine the work load which can be

endured. It is this external work load that is performed that determines the maximal energy expenditure. Duration of the multistage test is significantly related ($r = .514$, $p < .05$) to the MVO_2 . The aerobic power at submaximal loads decreased for both the AP and PI groups. This may be due to increased muscular efficiency of these groups.

Pulse oxygen increased in both groups at both maximal and submaximal loads. This may be due to either an increase in stroke volume or a widening of the A-V O_2 difference. Detry et al. (22) showed an increase in A-V O_2 difference but no increase in stroke volume. Submaximum stroke volume has been shown by Saltin (66) and Hartley et al. (37) to increase in normals. The increase in pulse oxygen may be due to stroke volume increases but is probably due to increases in A-V O_2 difference.

The maximum R.Q. did not change significantly in either the AP or PI groups.

The ST-segment depression in the AP group at maximum stress decreased in the AP patients over the 18 month training period. The ST-segment depression at submaximal loads decreased considerably in the AP group after training. This was due in part to a decrease in heart rate at the submaximum loads. ST depression was not a consistent observation in the PI group and hence is not discussed for that group.

The ST-segment-heart rate relationship improved in the AP group. This change could be explained by an increase in myocardial vascularization. The pre and post training coronary angiograms on

CHAPTER VI

SUMMARY AND CONCLUSIONS

SUMMARY

This study investigated the response of patients with angina pectoris and of those with old myocardial infarctions to an eighteen month program of endurance training. Twenty-seven angina patients (age 50 years) and nine "post-infarction" patients (age 50 years) were studied. These patients exercised using treadmills and bicycle ergometers. The angina patients trained at levels sufficient enough to evoke a myocardial hypoxic state. This level corresponded to 60-70% of their MVO_2 and was performed five days weekly. The "post-infarction" patients trained at work loads, corresponding to 70-80% of their MVO_2 , three days weekly. The ECG's of all patients were monitored continuously using oscilloscopes and recorded on an ECG recorder. Nurses, trained in intensive care units, monitored and supervised all training.

The maximal fitness measures of both groups improved. Increases in maximal heart rate, 11%, maximal measured aerobic power, 26%, oxygen pulse, 8%, and pressure-rate product, 9%, occurred in the angina group. Increases in maximal heart rate, 6.6%, measured aerobic power, 25%, oxygen-pulse, 17%, and pressure-rate product, 6%, occurred over the eighteen month period in the "post-infarction" group. The

three subjects showed marked increases in collateral circulation. The subjective evaluation of the change in ST-HR relationship for these three subjects also showed very marked improvement in this relationship. The other angina patients also showed improvement in their ST-HR relationship. However, most subjects showed very small changes and whether these small changes are paralleled by increases in collaterals is questionable. It may be due to a decrease in heart volume which Frick (32) found and related to decreased myocardial oxygen consumption. Whether the collaterals formed as a direct result of the training is questionable since collaterals have been shown to sometimes form as a result of the disease itself (68).

Plasma cholesterol and triglyceride levels did not change significantly over the 18 months in either the AP or PI groups. This is similar to the findings of Little (48) and Fox and Haskell (63,29).

Since there was no AP or PI group in this study which underwent the same treatment as these subjects did but without training, one can not state indisputably that the changes observed in this study occurred only as a result of the training. However, the results obtained in this study are similar in direction of change if not in exact magnitude of change to the results of other studies done on normals and "post-infarction" patients (17, 19, 20, 21, 22, 29, 30, 31, 32, 33, 37, 38, 39, 40, 48, 61). Thus one can be reasonably certain that the observed changes are due to the training program.

The "post-infarction" group was more fit ($\dot{M}\dot{V}O_2=2.31$ L/min) than the angina group ($\dot{M}\dot{V}O_2=1.8$ L/min), however the angina group showed slightly greater improvement over the training period. The duration of the multistage test increased 60% for the angina patients , to 511 seconds in the final test, and 50% for the "post-infarction" patients, to 695 seconds in the final test. The submaximal measures of fitness also improved. Decreases in the submaximal measures in stage I of $\dot{V}O_2$,7% , heart rate, 10%, blood pressure-heart rate product, 10%, and ST-segment depression, 85%, were shown to occur after training in the angina patients. The submaximal measures on the "post-infarction" patients also showed decreases in heart rate, 13%, pressure-rate product, 7%, and $\dot{V}O_2$, 20%.

There was an improvement in the ST-segment-heart rate relationship in the angina pectoris group. Pre and post training coronary angiograms in three patients showed an increase in the coronary collateral circulation. These increases in collateralization were paralleled by large improvements in the ST-HR relationship. Based on this observation it was thought that angina patients showing large increases in the ST-HR relationship would also have improved collateral circulation. It cannot, however, be concluded that the increased collateral circulation is a direct result of the training, because the other risk factors or confounding variables were not rigidly controlled. The plasma cholesterol and triglyceride levels did not decrease over the 18 month training period.

CONCLUSIONS

- (1) Patients with angina pectoris and "post-infarction" patients can exercise safely.
- (2) The fitness of angina patients and of "post-infarction" patients increases as shown by increases in maximal aerobic power, maximal heart rate, maximal tolerable work loads, maximal pressure-rate product, maximal pulse oxygen, duration of the multistage stress test and by decreases in the above measures at submaximal loads. The ST-segment depression-heart rate relationship is improved after an endurance training program and large changes in this improvement are paralleled by improvement in the coronary collateral circulation.

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APPENDIX

MAXIMUM VO₂ CONSUMPTION DETERMINATION

61

NAME _____ DATE _____
 AGE _____ HEIGHT _____ WEIGHT _____

Relative Humidity _____

Temperature _____

Blood Press. at Rest _____

Bar. Press. _____

Blood Press. 1-min. post exer. _____

TEST: Blood Press. _____ Heart Rate _____ Exp. Vol./Min. _____ Beckman _____ % CO₂ _____ R.Q. _____ VO₂ _____ VO₂/KG _____

EXERCISE	Blood Pressure Mins.	Time Interval	Heart Rate	Expired Volume	Beckman O ₂	% CO ₂	R.Q.	VO ₂	VO ₂ /KG
Stage I	1								
	2								
	3								
Stage II	4								
	5								
	6								
Stage III	7								
	8								
	9								
Stage IV	10								
	11								
	12								
Stage V	13								
	14								
	15								
Stage VI	16								
	17								
	18								
Stage VII	19								
	20								
	21								

RECOVERY: Heart Rate — 1 min. _____ 2 min. _____ 3 min. _____

1 min. Post _____

PATIENT QUESTIONNAIRE FORM

1. File No.
2. Examination Place
3. Date
4. Name
5. Father's Name
6. Birth Date
7. Occupation
8. Physical Activity (Professional)
(Light, Moderate or Heavy)
9. Height
10. Weight
11. Cigarette Smoking
12. Pipe Smoking
13. Cigar Smoking
14. If stopped, when?
15. Marital Status
16. No. of Children
17. Marriage Age
18. Alive or Cause of Death: Father Mother
19. Present Age or Age at Death: Father Mother
20. Diet
- (Routine, Reducing, Diabetic, ulcer, other special)
21. Sportive Activity: Type

MEDICAL HISTORY FORM

Name

Date

IS THERE A HISTORY OF:

Rheumatic Fever	Yes	No	Headache	Yes	No
Scarlet Fever	Yes	No	Blurred Vision	Yes	No
Diphtheria	Yes	No	Syncope	Yes	No
Bronchitis	Yes	No	Short of Breath:	Yes	No
Bronchial Asthma	Yes	No	— at rest		
Tuberculosis	Yes	No	— light effort		
Peptic Ulcer	Yes	No	— moderate effort		
Gall Bladder Disease	Yes	No	— severe effort		
Kidney Disease	Yes	No	Palpitation	Yes	No
Diabetes Mellitus	Yes	No	Any Chest Discomfort:	Yes	No
Liver Disease — Jaundice	Yes	No	— on effort		
Thyroid Disease	Yes	No	— on excitement		
Liver Disease	Yes	No	— after meals		
Arthritis	Yes	No	— others		
Stroke	Yes	No	Edema of Extremities:	Yes	No
			— varicose veins		
			— others: Explain		
			Surgery, if pertinent		
			— Age		
			— Illness		

HAS SUBJECT BEEN TOLD HE HAD:

Heart Attack	Yes	No	Year
Heart Trouble	Yes	No	Duration
Heart Murmur	Yes	No	
High Blood Pressure	Yes	No	

IS THERE A HISTORY OF:

Frequent involvement of chest with colds: Yes No
 — frequent cough
 — is there wheezing

Significant gastro-intestinal complaints Yes No

Genital-urinary complaints Yes No

FAMILY HISTORY, If any:

Parents

Grandparents

Siblings (specify which)

- heart attack
- other heart trouble
- high blood pressure
- stroke
- diabetes
- Others (specify)

1. Do you usually have great difficulty in falling asleep or staying asleep? Yes No
2. Do you find it impossible to take a regular rest period each day? Yes No
3. Do you find it impossible to take regular daily exercise? Yes No
4. Do you drink more than six cups of coffee or tea a day? Yes No
5. Do you usually take two or more alcoholic drinks a day? Yes No
6. Do you sweat or tremble a lot during examinations or questioning? Yes No
7. Do you get nervous and shaky when approached by a superior? Yes No
8. Does your work fall to pieces when the boss or a superior is watching you? Yes No
9. Does your thinking get completely mixed up when you have to do things quickly? Yes No
10. Must you do things very slowly in order to do them without mistakes? Yes No
11. Do you always get directions and orders wrong? Yes No
12. Do strange people or places make you afraid? Yes No
13. Are you scared to be alone when there are no friends near you? Yes No
14. Is it always hard for you to make up your mind? Yes No
15. Do you wish you always had someone at your side to advise you? Yes No
16. Are you considered a clumsy person? Yes No
17. Does it bother you to eat anywhere except in your own home? Yes No

18. Do you feel alone and sad at a party?	Yes	No
19. Do you usually feel unhappy and depressed?	Yes	No
20. Do you often cry?	Yes	No
21. Are you always miserable and blue?	Yes	No
22. Does life look entirely hopeless?	Yes	No
23. Do you often wish you were dead and away from it all?	Yes	No
24. Does worrying continually get you down?	Yes	No
25. Does worrying run in your family?	Yes	No
26. Does every little thing get on your nerves and wear you out?	Yes	No
27. Are you considered a nervous person?	Yes	No
28. Does nervousness run in your family?	Yes	No
29. Did you ever have a nervous breakdown?	Yes	No
30. Did anyone in your family ever have a nervous breakdown?	Yes	No
31. Were you ever a patient in a mental hospital (for your nerves)?	Yes	No
32. Was anyone in your family ever a patient in a mental hospital (for their nerves)?	Yes	No
33. Are you extremely shy or sensitive?	Yes	No
34. Do you come from a shy or sensitive family?	Yes	No
35. Are your feelings easily hurt?	Yes	No
36. Does criticism always upset you?	Yes	No
37. Do people usually misunderstand you?	Yes	No
38. Are you considered a touchy person?	Yes	No
39. Do you have to be on guard even with your friends?	Yes	No
40. Do you always do things on sudden impulse?	Yes	No
41. Are you easily upset or irritated?	Yes	No
42. Do you go to pieces if you don't constantly control yourself?	Yes	No
43. Do little annoyances get on your nerves and make you angry?	Yes	No
44. Does it make you angry to have anyone tell you what to do?	Yes	No
45. Do people often annoy or irritate you?	Yes	No
46. Do you flare up in anger if you can't have what you want right away?	Yes	No
47. Do you often get into a violent rage?	Yes	No
48. Do you often shake or tremble?	Yes	No
49. Are you constantly keyed up and jittery?	Yes	No
50. Do sudden noises make you jump or shake badly?	Yes	No
51. Do you tremble or feel weak whenever someone shouts at you?	Yes	No
52. Do you become scared at sudden movements or noises at night?	Yes	No
53. Are you often awakened out of your sleep by frightening dreams?	Yes	No
54. Do frightening thoughts keep coming back in your mind?	Yes	No
55. Do you often become suddenly scared for no good reason?	Yes	No
56. Do you often break out in a cold sweat?	Yes	No

TABLE X:
CORRELATION MATRIX FOR POST INFARCTION PATIENTS

	1	2	3	4	5	6	7	8	9	10
1										
2	-.42									
3	.44	.69								
4	.23	.85	<u>.96</u>							
5	-.35	.50	<u>.05</u>	.04						
6	-.09	.15	.09	.01	<u>.87</u>					
7	.16	-.52	-.03	-.14	<u>.39</u>	<u>.74</u>				
8										
9	-.21	.51	.52	.60	.70	<u>.69</u>	.30			
10	-.36	-.28	-.50	-.55	.52	<u>.70</u>	.76	.16		
11	-.27	-.27	-.49	-.58	.52	<u>.63</u>	<u>.66</u>	-.02	<u>.93</u>	
12	.12	-.27	-.50	-.50	.49	.52	.53	-.01	.56	
13	-.13	.40	-.78	-.89	.29	.08	-.26	.22	-.08	
14	<u>.66</u>	<u>-.71</u>	.16	-.07	-.38	-.08	.34	-.43	.05	
15	.53	-.32	.17	.02	-.56	-.45	-.23	-.39	-.39	
16	.48	-.22	.65	.54	.32	.47	.56	.38	.08	
17	.22	.07	.64	.62	.55	.63	.52	<u>.74</u>	.11	
18	-.15	-.07	-.02	-.14	.50	.57	.52	.23	<u>.60</u>	
19	-.11	-.02	-.10	-.23	<u>.66</u>	<u>.74</u>	.60	.28	<u>.71</u>	
	11	12	13	14	15	16	17	18	19	
11										
12	<u>.72</u>									
13	.03	.39								
14	.20	.30	-.03							
15	-.24	.01	.39	<u>.75</u>						
16	.16	.43	.13	<u>.54</u>	.27					
17	.03	.20	.22	.19	.02	<u>.90</u>				
18	<u>.70</u>	.61	.47	.20	.20	<u>.54</u>	.40			
19	<u>.81</u>	<u>.74</u>	.42	.31	.02	.51	.49	<u>.95</u>		

Scores which are underlined are significant at the .05 level of confidence.

The numbers chosen and the variables which they represent are as follows: 1 - age, 2 - maximum heart rate (test I), 3 - maximum blood pressure (test I), 4 - blood pressure-heart rate product (test I), 5 - MVO_2 initial test, 6 - MVO_2/kg initial test, 7 - pulse oxygen, 8 - R.Q., 9 - duration of initial multistage test, 10 - initial training bike load, 11 - mean training bike load, 12 - initial training heart

rate, 13 - mean training heart rate, 14 - initial training pressure
x rate product, 15 - mean training pressure x rate product, 16 -
initial cholesterol level, 17 - mean cholesterol level, 18 - initial
triglyceride levels, 19 - mean triglyceride levels.

TABLE XI:
CORRELATION MATRIX FOR ANGINA PATIENTS

	1	2	3	4	5	6	7	8	9	10	11
1											
2	-.40										
3	-.21	.16									
4	-.30	<u>.60</u>	<u>.79</u>								
5	-.29	.15	.10	.21							
6	-.29	-.03	.09	.06	<u>.84</u>						
7	-.00	<u>.44</u>	-.16	-.35	<u>.63</u>	<u>.83</u>					
8	-.25	-.34	-.67	-.41	<u>.76</u>	<u>.68</u>	<u>.87</u>				
9	-.04	.09	-.48	-.26	<u>.51</u>	<u>.51</u>	<u>.56</u>	.38			
10	.08	.13	-.27	-.10	<u>.59</u>	<u>.42</u>	<u>.35</u>	<u>.79</u>	<u>.67</u>		
11	.16	-.20	.13	.20	<u>.42</u>	<u>.42</u>	<u>.46</u>	.27	<u>.52</u>	<u>.75</u>	
12	.05	.10	-.44	-.51	-.07	-.16	-.10	.12	<u>.59</u>	<u>.65</u>	.21
13	-.31	.24	-.48	-.50	-.11	-.24	-.20	-.06	-.38	-.45	<u>.57</u>
14	.10	.17	.38	.05	-.03	-.13	-.17	-.36	.02	-.02	-.37
15	-.14	.13	<u>.79</u>	.42	-.10	-.15	-.16	<u>.97</u>	-.63	-.71	-.49
16	-.33	.15	.14	.04	-.13	-.31	-.36	-.61	-.14	-.36	-.32
17	-.30	.08	.06	-.06	-.15	-.37	-.42	-.34	-.32	-.33	-.30
18	-.36	-.12	.14	-.05	.11	.19	.13	-.02	.06	.10	.00
19	-.11	.13	.11	-.00	<u>.49</u>	.22	.07	.32	.02	.00	-.36
20	-.09	-.28	-.05	-.30	.26	.41	<u>.49</u>	-.60	.38	.12	.32
21	-.11	<u>.50</u>	.02	-.40	.05	.30	<u>.44</u>	-.33	-.37	-.39	-.19
22	-.32	<u>.38</u>	.14	.41	.49	.46	.35	<u>.91</u>	.38	.51	.65
	12	13	14	15	16	17	18	19	20	21	22
12											
13	-.31										
14	.26	.05									
15	-.83	<u>.64</u>	.05								
16	.12	.08	<u>.41</u>	<u>.42</u>							
17	.11	.06	.28	.29	<u>.91</u>						
18	.37	.31	-.02	-.10	-.19	-.10					
19	.27	.10	<u>.58</u>	.24	<u>.33</u>	<u>.40</u>	.07				
20	-.19	-.06	-.23	-.12	-.17	-.16	-.02	-.07			
21	-.47	<u>.44</u>	-.06	.51	-.07	-.09	.12	.07	.34		
22	<u>.47</u>	<u>.61</u>	.60	.52	-.21	-.09	.14	.11	.31	.62	

Scores which are underlined are significant at the .05 level of confidence.

The numbers chosen and the variables which they represent are as follows: 1 - age, 2 - maximum heart rate (test I), 3 - maximum blood pressure (test I), 4 - blood pressure-heart rate product (test I), 5 - MVO_2 initial test, 6 - MVO_2/kg initial test, 7 - pulse oxygen,

8 - R.Q., 9 - duration of initial multistage test, 10 - initial training bike load, 11 - mean training bike load, 12 - initial training heart rate, 13 - mean training heart rate, 14 - initial training pressure x rate product, 15 - mean training pressure x rate product, 16 - initial cholesterol level, 17 - mean cholesterol level, 18 - initial triglyceride levels, 19 - mean triglyceride levels, 20 - initial test maximum ST depression, 21 - change in ST-segment-heart rate relationship, 22 - change in maximum heart rate.

Computer programs Used for the

Statistical Analysis

The program DERS: ANOV 14 from University of Alberta, Department of Educational Research Services was used for the analysis of variance with repeated measures and AFTRAN subroutine to account for missing data.

```

$SIGNON
XXXXXX
$COPY SOURCE TO-TEMP
    data cards
$RUN    *FORTG
        SUBROUTINE DFTRAN (I, X)
        DIMENSION X (1)
        I = 1
        IF (X(1).LT.0.) RETURN
        I = -1
        IF (X(1).EQ.0.OR.X(2).EQ.0.) RETURN
        I = 0
        RETURN
        END
$SOURCE DERS:ANOV 14

```

title, parameter and format cards

The program DERS: DEST05 from the University of Alberta, Department of Educational Research Services was used for the correlation matrix. The DATRAN subroutine was used to account for missing data.

```

$SIGNON
XXXXXX
$RUN    *FORTG
        SUBROUTINE DATRAN (X,Y)
        DIMENSION X(1), Y(1)
        DATA BLANK /' '/
        DO 1 I = 1, --
        IF (X(I).EQ.0.) Y(I) = BLANK
1 CONTINUE
        RETURN
        END
$END FILE
$SOURCE DERS:DEST05

```

title, parameter, format and data cards

TABLE XII: Parameters for Subjective evaluation of Improvement of ST-HR Relationship

Initial Test			12 month test			Subjective measure of change in ST-HR relationship
Min. H.R. with S-T segment dep.	Approx. slope of ST-HR line (mm/100 beat)	Max. H.R.	Min. H.R. with S-T segment dep.	Approx. slope of ST-HR line (mm/100 beat)	Max. H.R.	
115	20	149	140	2.2	173	4
87	5	122	98	4.5	127	3
102	5	125	111	3.3	134	4
108	10	129	94	5.5	134	2
*105	20	124	115	5	148	6
123	20	135	132	4	161	6
126	4	164	105	2.5	164	2
125	6	150	134	2	158	5
102	10	113	90	3	127	3
115	10	138	114	3	154	4
*114	21	124	130	10	143	6
87	7.5	118	87	10	113	-1
*105	7.5	117	98	2.5	149	6
102	8.5	129	115	10	130	2
117	10	148	118	5	148	4
117	5	141	117	3.3	145	2
120	2.4	161	141	3.3	162	3
92	7	129	118	4	150	5
105	6.4	132	103	4.8	120	2
123	4.5	167	127	4.4	176	1
102	8.2	125	114	8.0	132	3
143	2.5	164	148	3.8	164	-1
98	2.5	136	134	4.5	148	2

* Subjects had pre and post training angiograms.

RAW DATA
FOR
ANGINA PECTORIS
PATIENTS

SUBJECT: I. W. 1912 151-157
 BIRTHDATE WEIGHT(range)

MULTISTAGE TEST

Variable	Time in Months			
	0	6	12	18
Maximum -				
Duration of Test (secs)	120	360	360	-
Heart rate (beats/min)	141	134	142	-
Systolic pressure (mmHg)	-	160	-	-
Pressure x Rate product (/100)	-	214	-	-
ST-segment depression (mV).....	1.8	1.8	-	-
VO ₂ (L/min)	1.104	1.270	1.020	-
VO ₂ /wt. (ml/kg/min)	15.57	17.80	14.52	-
Pulse oxygen (ccO ₂ /kg/beat)....	.1004	.1328	.1008	-
R. Q.	-	1.01	1.18	-
Submaximum - <u>Stage I</u>				
Heart rate - (beats/min)	141	115	114	-
Systolic Pressure (mm Hg)	-	170	142	-
Pressure x Rate product (/100)	-	196	162	-
ST-segment depression (mV).....	1.8	1.1	-	-
VO ₂ (L/min)	1.104	1.162	1.030	-
VO ₂ /wt. (ml/kg/min).....	15.57	16.30	14.62	-
Pulse oxygen (ccO ₂ /kg/beat)....	.1004	.1417	.1282	-
R. Q.	-	.86	.83	-

DAILY TRAINING

	Time in Months			
	0	6	12	18
<u>BICYCLE ERGOMETER</u>				
Load (kpm/min)	300	450	450	450
Heart rate (beats/min)	108	122	110	115
Systolic pressure (mmHg)	120	110	110	110
Pressure x Rate (/100)	130	134	121	127
<u>TREAD MILL</u>				
Speed (mph)	2.6	3.6	3.9	4.0
Elevation (%)	0	0	0	2
Heart rate (beats/min)	108	110	108	107
Systolic Pressure (mmHg).....	110	110	110	90
Pressure x Rate (/100)	119	121	119	96
Plasma Cholesterol (mg%)	200	244	226	-
Plasma Triglycerides (mg%)	142	76	105	-

Subjective evaluation of change in ST-HR relationship: 2

SUBJECT..... S. K. 1924 152-158
 BIRTH DATE..... WEIGHT(range).....

MULTISTAGE TEST

Variable	Time in Months			
	0	6	12	18
Maximum -				
Duration of Test (secs).....	360	-	525	-
Heart rate (beats/min)	161	-	161	-
Systolic pressure (mmHg).....	150	-	142	-
Pressure x Rate product (/100)	233	-	229	-
ST-segment depression (mV)....	1.4	-	1.5	-
VO ₂ (L/min)	1.240	-	1.970	-
VO ₂ /wt. (ml/kg/min)	18.08	-	27.10	-
Pulse oxygen (ccO ₂ /kg/beat).. R. Q.	.1113 -	- -	.1683 .99	- -
Submaximum - Stage I				
Heart rate - (beats/min)	129	-	115	-
Systolic Pressure (mm Hg) ...	135	-	120	-
Pressure x Rate product (/100)	174	-	138	-
ST-segment depression (mV)....	0.5	-	0.1	-
VO ₂ (L/min)	.899	-	1.020	-
VO ₂ /wt. (ml/kg/min)	13.08	-	14.10	-
Pulse oxygen (ccO ₂ /kg/beat).. R. Q.	.1013 -	- -	.1226 .73	- -

DAILY TRAINING

	Time in Months			
	0	6	12	18
<u>BICYCLE ERGOMETER</u>				
Load (kpm/min)	450	525	600	600
Heart rate (beats/min)	124	125	133	138
Systolic pressure (mmHg).....	110	110	100	120
Pressure x Rate (/100)	136	138	133	166
<u>TREAD MILL</u>				
Speed (mph)	3.4	3.8	3.8	4.2
Elevation (%)	0	5	7	4
Heart rate (beats/min)	108	125	130	120
Systolic Pressure (mmHg).....	110	100	115	95
Pressure x Rate (/100)	136	125	150	114
Plasma Cholesterol (mg%)	308	338	325	-
Plasma Triglycerides (mg%)	154	132	148	-

Subjective evaluation of change in ST-HR relationship: 3

SUBJECT:.....L. T-B.....1921.....175-178
 BIRTH DATE.....WEIGHT(range).....

MULTISTAGE TEST

Variable	Time in Months			
	0	6	12	18
Maximum -				
Duration of Test (secs)	420	465	540	-
Heart rate (beats/min)	164	164	164	-
Systolic pressure (mmHg).....	200	235	210	-
Pressure x Rate product (/100)	272	372	332	-
ST-segment depression (mV).....	2.0	-	1.7	-
VO ₂ (L/min)	1.623	1.776	1.960	-
VO ₂ /wt. (ml/kg/min)	20.10	22.64	24.76	-
Pulse oxygen (ccO ₂ /kg/beat)....	.1473	.1432	.1567	-
R. Q.	-	.95	1.02	-
Submaximum - Stage I				
Heart rate - (beats/min)	129	114	113	-
Systolic Pressure (mm Hg)	200	190	210	-
Pressure x Rate product (/100).	258	217	237	-
ST-segment depression (mV).....	.4	-	.4	-
VO ₂ (L/min)	1.300	1.143	1.030	-
VO ₂ /wt. (ml/kg/min)	16.10	14.57	13.03	-
Pulse oxygen (ccO ₂ /kg/beat)....	.1248	.1278	.1153	-
R. Q.	-	.78	.76	-

DAILY TRAINING

	Time in Months			
	0	6	12	18
<u>BICYCLE ERGOMETER</u>				
Load (kpm/min)	450	675	750	750
Heart rate (beats/min)	95	115	110	122
Systolic pressure (mmHg).....	137	159	140	160
Pressure x Rate (/100).....	130	183	154	195
<u>TREAD MILL</u>				
Speed (mph)	3.4	3.6	4.0	4.2
Elevation (%)	0	5	2	2
Heart rate (beats/min)	105	117	105	108
Systolic Pressure (mmHg).....	145	154	140	160
Pressure x Rate (/100)	152	180	147	173
Plasma Cholesterol (mg%).....	168	-	178	187
Plasma Triglycerides (mg%)	68	-	92	103

Subjective evaluation of change in ST-HR relationship: 2

1926

166-172

SUBJECT:.....R...C.....BIRTH DATE.....WEIGHT(range).....

MULTISTAGE TEST

Variable	Time in Months			
	<u>0</u>	<u>6</u>	<u>12</u>	<u>18</u>
Maximum -				
Duration of Test (secs)	360	-	420	-
Heart rate (beats/min)	124	-	148	-
Systolic pressure (mmHg)	145	-	120	-
Pressure x Rate product (/100)	175	-	169	-
ST-segment depression (mV).....	2.5	-	3.5	-
VO ₂ (L/min).....	1.509	-	1.750	-
VO ₂ /wt. (ml/kg/min)	19.34	-	23.15	-
Pulse oxygen (ccO ₂ /kg/beat)....	.1585	-	.1641	-
R. Q.	.86	-	.87	-
Submaximum - <u>Stage I</u>				
Heart rate - (beats/min)	104	-	118	-
Systolic Pressure (mm Hg)	140	-	112	-
Pressure x Rate product (/100)	146	-	132	-
ST-segment depression (mV).....	.6	-	.4	-
VO ₂ (L/min)	.949	-	1.010	-
VO ₂ /wt. (ml/kg/min)	12.16	-	13.24	-
Pulse oxygen (ccO ₂ /kg/beat)....	.1169	-	.1122	-
R. Q.	.83	-	.78	-

DAILY TRAINING

	Time in Months			
	<u>0</u>	<u>6</u>	<u>12</u>	<u>18</u>
<u>BICYCLE ERGOMETER</u>				
Load (kpm/min)	450	450	525	600
Heart rate (beats/min).....	125	122	128	130
Systolic Pressure (mmHg).....	120	105	110	110
Pressure x rate (/100).....	150	128	141	143
<u>TREAD MILL</u>				
Speed (mph)	3.8	3.7	3.8	3.8
Elevation (%)	0	0	4	4
Heart rate (beats/min)	118	122	125	122
Systolic Pressure (mmHg).....	105	105	110	107
Pressure x Rate (/100)	124	128	138	131
Plasma Cholesterol (mg%)	242	290	267	272
Plasma Triglycerides (mg%)	280	280	204	196

Subjective evaluation of change in ST-HR relationship: 6

Coronary angiograms pre and post were performed.

P. H.

1922

152-157

SUBJECT.....BIRTH DATE.....WEIGHT(range).....

MULTISTAGE TEST

Variable	Time in Months			
	0	6	12	18
Maximum -				
Duration of Test (secs)	300	540	600	-
Heart rate (beats/min)	135	141	161	-
Systolic pressure (mmHg)	180	180	182	-
Pressure x Rate product (/100)	198	254	288	-
ST-segment depression (mV)	2.9	-	1.5	-
VO ₂ (L/min)	1.539	1.681	2.070	-
VO ₂ /wt. (ml/kg/min)	21.84	24.37	29.07	-
Pulse oxygen (ccO ₂ /kg/beat)....	.1719	.1728	.1840	-
R. Q.	-	1.13	1.07	-
Submaximum - <u>Stage I</u>				
Heart rate - (beats/min)	105	113	103	-
Systolic Pressure (mm Hg)	-	145	150	-
Pressure x Rate product (/100).	-	164	155	-
ST-segment depression (mV).....	.0	-	0	-
VO ₂ (L/min)	1.039	.930	1.110	-
VO ₂ /wt. (ml/kg/min)	10.74	13.44	15.57	-
Pulse oxygen (ccO ₂ /kg/beat) ...	.1404	.1189	.1510	-
R. Q.	-	.81	.82	-

DAILY TRAINING

	Time in Months			
	0	6	12	18
<u>BICYCLE ERGOMETER</u>				
Load (kpm/min)	450	525	675	750
Heart rate (beats/min)	110	120	120	122
Systolic pressure (mm Hg).....	130	130	120	140
Pressure x Rate (/100)	143	156	144	171
<u>TREAD MILL</u>				
Speed (mph)	3.5	3.8	4.0	4.2
Elevation (%)	0	4	2	2
Heart rate (beats/min)	110	120	120	122
Systolic Pressure (mmHg)	122	120	120	122
Pressure x Rate (/100).....	132	144	144	149
Plasma Cholesterol (mg%).....	223	305	198	-
Plasma Triglycerides (mg%).....	130	181	106	-

Subjective evaluation of Change in ST-HR relationship:

SUBJECT.....A. M.....1913.....180-182
 BIRTH DATE.....WEIGHT(range).....

MULTISTAGE TEST

Variable	Time in Months			
	0	6	12	18
Maximum -				
Duration of Test (secs).....	300	735	750	-
Heart rate (beats/min)	112	118	127	-
Systolic pressure (mmHg).....	-	180	160	-
Pressure x Rate product (/100)	-	212	204	-
ST-segment depression (mV)....	2.3	-	2.4	-
VO ₂ (L/min)	1.531	1.811	1.790	-
VO ₂ /wt. (ml/kg/min).....	18.52	21.94	21.96	-
Pulse oxygen (ccO ₂ /kg/beat)...	.1569	.1817	.1729	-
R. Q.	-	.94	.99	-
Submaximum - Stage I				
Heart rate - (beats/min)	90	80	72	-
Systolic Pressure (mm Hg).....	-	160	120	-
Pressure x Rate product (/100)	-	128	86	-
ST-segment depression (mV)....	1.0	-	.1	-
VO ₂ (L/min)	1.100	.990	1.040	-
VO ₂ /wt. (ml/kg/min)	12.50	11.97	12.75	-
Pulse oxygen (ccO ₂ /kg/beat)...	.1388	.1496	.1771	-
R. Q.	-	.80	.72	-

DAILY TRAINING

	Time in Months			
	0	6	12	18
<u>BICYCLE ERGOMETER</u>				
Load (kpm/min)	375	625	900	900
Heart rate (beats/min)	93	105	115	112
Systolic pressure (mmHg)	121	150	140	160
Pressure x Rate (/100)	113	158	161	179
<u>TREAD MILL</u>				
Speed (mph)	2.6	3.6	4.2	4.4
Elevation (%)	0	4	6	6
Heart rate (beats/min)	93	105	115	107
Systolic Pressure (mmHg)	121	130	140	130
Pressure x Rate (/100)	113	137	161	139
Plasma Cholesterol (mg%)	296	394	293	241
Plasma Triglycerides (mg%)	95	186	127	112

Subjective evaluation of change in ST-HR relationship:

A. Z. 1920 174-179
 SUBJECT.....BIRTH DATE.....WEIGHT(range)

MULTISTAGE TEST

Variable	Time in Months			
	0	6	12	18
Maximum -				
Duration of Test (secs)	300	450	600	-
Heart rate (beats/min)	150	143	158	-
Systolic pressure (mmHg)	200	180	208	-
Pressure x Rate product (/100)	300	272	320	-
ST-segment depression (mV)....	1.4	-	.7	-
VO ₂ (l/min)	1.862	1.887	2.450	-
VO ₂ /wt. (ml/kg/min).....	22.89	23.11	30.48	-
Pulse oxygen (ccO ₂ /kg/beat)...	.1601	.1616	.1974	-
R. Q.	-	.94	1.07	-
Submaximum - Stage I				
Heart rate - (beats/min)	129	96	105	-
Systolic Pressure (mm Hg).....	-	170	180	-
Pressure x Rate product (/100)	-	162	189	-
ST-segment depression (mV)....	.9	-	0	-
VO ₂ (l/min).....	1.439	.964	1.140	-
VO ₂ /wt. (ml/kg/min)	17.69	12.36	14.17	-
Pulse oxygen (ccO ₂ /kg/beat)...	.1371	.1295	.1350	-
R. Q.	-	.98	.78	-

DAILY TRAINING

	Time in Months			
	0	6	12	18
<u>BICYCLE ERGOMETER</u>				
Load (kpm/min).....	600	825	900	-
Heart rate (beats/min)	115	116	112	-
Systolic pressure (mmHg)	150	150	146	-
Pressure x Rate (/100)	173	174	164	-
<u>TREAD MILL</u>				
Speed (mph)	3.6	3.8	4.4	-
Elevation (%)	0	6	6	-
Heart rate (beats/min)	115	122	112	-
Systolic Pressure (mmHg).....	160	160	160	-
Pressure x Rate (/100)	184	195	179	-
Plasma Cholesterol (mg%)	243	244	241	-
Plasma Triglycerides (mg%)	262	258	104	-

Subject evaluation of Change in ST -HR relationship:

SUBJECT.....J. W.....1923.....152-156
 BIRTH DATE.....WEIGHT(range)

MULTISTAGE TEST

Variable	Time in Months			
	0	6	12	18
Maximum -				
Duration of Test (secs)	330	495	-	-
Heart rate (beats/min)	113	127	-	-
Systolic pressure (mmHg)	-	175	-	-
Pressure x Rate product (/100)	-	215	-	-
ST-segment depression (mV)....	2.0	1.7	-	-
VO ₂ (L/min)	1.136	1.762	-	-
VO ₂ /wt. (ml/kg/min)	16.16	25.20	-	-
Pulse oxygen (ccO ₂ /kg/beat)...	.1393	.2020	-	-
R. Q.	-	.94	-	-
Submaximum - Stage I				
Heart rate - (beats/min)	97	87	-	-
Systolic Pressure (mm Hg) ...	-	135	-	-
Pressure x Rate product (/100)	-	117	-	-
ST-segment depression (mV)....	.8	.3	-	-
VO ₂ (L/min)	.840	.656	-	-
VO ₂ /wt. (ml/kg/min)	13.00	9.38	-	-
Pulse oxygen (ccO ₂ /kg/beat)...	.1342	.0801	-	-
R. Q.	-	-	-	-

DAILY TRAINING

	Time in Months			
	0	6	12	18
<u>BICYCLE ERGOMETER</u>				
Load (kpm/min)	300	450	750	-
Heart rate (beats/min).....	107	115	110	-
Systolic pressure (mmHg).....	140	140	140	-
Pressure x Rate (/100)	151	161	154	-
<u>TREAD MILL</u>				
Speed (mph)	2.8	3.4	4.0	-
Elevation (%)	0	0	5	-
Heart rate (beats/min)	100	108	105	-
Systolic Pressure (mmHg).....	120	140	140	-
Pressure x Rate (/100)	120	151	147	-
Plasma Cholesterol (mg%).....	316	268	-	-
Plasma Triglycerides (mg%)	106	107	-	-

Subject evaluation of change in ST-HR relationship:

SUBJECT:.....D. O. 1926 184-187
 BIRTH DATE.....WEIGHT(range)

MULTISTAGE TEST

Variable	Time in Months			
	0	6	12	18
Maximum -				
Duration of Test (secs).1.....	420	-	430	-
Heart rate (beats/min)	129	-	130	-
Systolic pressure (mmHg)	190	-	198	-
Pressure x Rate product (/100)	247	-	257	-
ST-segment depression (mV)....	2.8	-	2.1	-
VO ₂ (L/min)	1.981	-	1.890	-
VO ₂ /wt. (ml/kg/min).....	23.36	-	22.62	-
Pulse oxygen (ccO ₂ /kg/beat) ..	.1810	-	.1740	-
R. Q.	.92	-	.93	-
Submaximum - Stage I				
Heart rate - (beats/min)	102	-	113	-
Systolic Pressure (mm Hg).....	160	-	170	-
Pressure x Rate product (/100)	160	-	192	-
ST-segment depression (mV)....	.5	-	.4	-
VO ₂ (L/min)	1.182	-	1.260	-
VO ₂ /wt. (ml/kg/min)	13.94	-	15.16	-
Pulse oxygen (ccO ₂ /kg/beat) ..	.1367	-	.1341	-
R. Q.	.78	-	.83	-

DAILY TRAINING

	Time in Months			
	0	6	12	18
<u>BICYCLE ERGOMETER</u>				
Load (kpm/min)	450	450	600	600
Heart rate (beats/min).....	128	120	125	118
Systolic pressure (mmHg)	135	124	120	120
Pressure x Rate (/100)	173	149	150	142
<u>TREAD MILL</u>				
Speed (mph)	3.6	3.9	4.2	4.4
Elevation (%)	0	0	4	4
Heart rate (beats/min)	122	118	117	108
Systolic Pressure (mmHg)	150	135	120	130
Pressure x Rate (/100)	183	159	140	140
Plasma Cholesterol (mg%)	268	354	216	-
Plasma Triglycerides (mg%)	335	257	225	-

Subjective evaluation of change in ST-HR relationship:

SUBJECT:..... J. T. 1918 153-155
 BIRTH DATE..... WEIGHT(range)

MULTISTAGE TEST

Variable	Time in Months			
	0	6	12	18
Maximum -				
Duration of Test (secs)	345	420	-	-
Heart rate (beats/min)	129	150	-	-
Systolic pressure (mmHg)	200	210	-	-
Pressure x Rate product (/100)	244	311	-	-
ST-segment depression (mV)....	3.4	1.6	-	-
VO ₂ (L/min)	1.247	1.570	-	-
VO ₂ /wt. (ml/kg/min)	17.40	27.66	-	-
Pulse oxygen (ccO ₂ /kg/beat)...	.1467	.1531	-	-
R. Q.	1.09	.89	-	-
Submaximum - Stage I				
Heart rate - (beats/min)	95	115	-	-
Systolic Pressure (mm Hg)	200	180	-	-
Pressure x Rate product (/100)	190	201	-	-
ST-segment depression (mV)....	.8	.2	-	-
VO ₂ (L/min)	.968	.980	-	-
VO ₂ /wt. (ml/kg/min)	13.90	14.27	-	-
Pulse oxygen (ccO ₂ /kg/beat) ..	.1463	.1240	-	-
R. Q.	1.00	.89	-	-

DAILY TRAINING

	Time in Months			
	0	6	12	18
<u>BICYCLE ERGOMETER</u>				
Load (kpm/min)	225	600	675	675
Heart rate (beats/min)	95	120	115	123
Systolic pressure (mmHg)	145	170	160	175
Pressure x Rate (/100)	138	204	184	215
<u>TREAD MILL</u>				
Speed (mph)	2.2	3.6	4.0	4.0
Elevation (%)	0	5	4	0
Heart rate (beats/min)	90	120	105	103
Systolic Pressure (mmHg)	130	180	145	125
Pressure x Rate (/100)	117	216	152	129
Plasma Cholesterol (mg%)	240	228	282	268
Plasma Triglycerides (mg%)	218	104	116	166

Subjective evaluation of change in ST-HR relationship: 5

SUBJECTA. A. BIRTH DATE1914 WEIGHT (range)169-170

MULTISTAGE TEST

Variable	Time in Months			
	0	6	12	18
Maximum -				
Duration of Test (secs)	465	-	465	-
Heart rate (beats/min)	132	-	120	-
Systolic Pressure (mmHg)	120	-	124	-
Pressure x Rate product (/100)	163	-	149	-
ST-segment depression (mV) ...	2.0	-	1.1	-
VO ₂ (L/min)	1.510	-	1.680	-
VO ₂ /wt. (ml/kg/min)	20.77	-	23.08	-
Pulse oxygen (ccO ₂ /kg/beat)... 2	.1928	-	.1923	-
R. Q.	.94	-	.77	-

Submaximum-Stage I

Heart rate - (beats/min).....	75	-	78	-
Systolic Pressure (mm Hg)	125	-	106	-
Pressure x Rate product (/100)	96	-	83	-
ST-segment depression (mV) ...	.1	-	.1	-
VO ₂ (L/min)	1.085	-	.970	-
VO ₂ /wt. (ml/kg/min)	14.07	-	13.34	-
Pulse oxygen (ccO ₂ /kg/beat)... 2	.1876	-	.1780	-
R. Q.	.68	-	.75	-

DAILY TRAINING

	Time in Months			
	0	6	12	18
<u>BICYCLE ERGOMETER</u>				
Load (kpm/min)	400	500	600	675
Heart rate (beats/min)	114	120	120	125
Systolic pressure (mmHg).....	-	-	-	-
Pressure x Rate (/100)	-	-	-	-
<u>TREAD MILL</u>				
Speed (mph).....	3.4	3.5	4.2	4.5
Elevation (%)	0	6	10	6
Heart rate (beats/min)	110	109	120	125
Systolic Pressure (mmHg)	-	-	-	-
Pressure x Rate (/100)	-	-	-	-
Plasma Cholesterol (mg%)	212	-	196	196
Plasma Triglycerides (mg%)	142	-	133	133

Subjective evaluation of change in ST-HR relationship:

SUBJECT G. A. 1922 187-193 85
 BIRTH DATE WEIGHT(range)

MULTISTAGE TEST

Variable	Time in Months			
	0	6	12	18
Maximum -				
Duration of Test (secs)	420	660	510	-
Heart rate (beats/min)	167	180	176	-
Systolic pressure (mmHg)	140	160	170	-
Pressure x Rate product (/100)	225	288	289	-
ST-segment depression (mV) ...	2.9	3.5	3.1	-
VO ₂ (L/min)	1.540	2.233	2.430	-
VO ₂ /wt. (ml/kg/min)	18.14	26.70	27.79	-
Pulse oxygen (ccO ₂ /kg/beat) ..	.1210	.1480	.1635	-
R. Q.	-	.95	.94	-
Submaximum - Stage I				
Heart rate - (beats/min)	125	108	122	-
Systolic Pressure (mm Hg)	105	120	130	-
Pressure x Rate product (/100)	131	130	159	-
ST-segment depression (mV) ...	1.2	.1	.7	-
VO ₂ (L/min)	1.149	.751	1.160	-
VO ₂ /wt. (ml/kg/min)	13.52	8.62	13.25	-
Pulse oxygen (ccO ₂ /kg/beat) ..	.1082	.0798	.1086	-
R. Q.	-	.93	.70	-

DAILY TRAINING

	Time in Months			
	0	6	12	18
<u>BICYCLE ERGOMETER</u>				
Load (kpm/min)	525	525	600	675
Heart rate (beats/min)	125	120	125	135
Systolic pressure (mmHg)	110	100	110	110
Pressure x Rate (/100)	138	120	138	149
<u>TREAD MILL</u>				
Speed (mph)	3.9	3.6	3.9	4.2
Elevation (%)	0	3	3	4
Heart rate (beats /min)	133	117	120	135
Systolic Pressure (mmHg)	110	100	110	105
Pressure x Rate (/100)	146	117	132	142
Plasma Cholesterol (mg%)	230	-	230	-
Plasma Triglycerides (mg%)	-	-	-	-

Subjective evaluation of change in ST-HR relationship:

SUBJECT A. H. BIRTH DATE 1906 WEIGHT (range) 173-185 86

MULTISTAGE TEST

Variable	Time in Months			
	0	6	12	18
Maximum -				
Duration of Test (secs)	360	465	450	-
Heart rate (beats/min)	122	129	130	-
Systolic pressure (mmHg)	-	140	140	-
Pressure x Rate product (/100)	-	161	180	-
ST-segment depression (mV)	2.0	-	2.0	-
VO ₂ (L/min)	1.381	2.056	1.760	-
VO ₂ /wt. (ml/kg/min)	16.43	26.06	22.42	-
Pulse oxygen (ccO ₂ /kg/beat) ...	.1347	.2020	.1724	-
R. Q.	-	.94	1.04	-
Submaximum - Stage I				
Heart rate - (beats/min)	100	98	95	-
Systolic Pressure (mm Hg)	-	110	130	-
Pressure x Rate product (/100)	-	108	124	-
ST-segment depression (mV)	.3	-	.1	-
VO ₂ (L/min)	1.084	1.063	1.140	-
VO ₂ /wt. (ml/kg/min)	12.89	13.62	1.471	-
Pulse oxygen (ccO ₂ /kg/beat) ..	.1290	.1230	.1548	-
R. Q.	-	.84	.74	-

DAILY TRAINING

	Time in Months			
	0	6	12	18
<u>BICYCLE ERGOMETER</u>				
Load (kpm/min)	450	600	750	750
Heart rate (beats/min)	110	116	124	124
Systolic pressure (mmHg)	120	135	140	140
Pressure x Rate (/100)	132	157	174	174
<u>TREAD MILL</u>				
Speed (mph)	3.2	3.9	4.0	4.2
Elevation (%)	0	0	6	6
Heart Rate (beats/min)	103	110	120	118
Systolic Pressure (mmHg)	100	130	145	140
Pressure x Rate (/100)	103	143	174	165
Plasma Cholesterol (mg%)	196	-	233	-
Plasma Triglycerides (mg%)	-	-	106	-

Subjective evaluation of change in ST-HR relationship:

W. K. 1918 154-160
 SUBJECT BIRTH DATE WEIGHT(range)

MULTISTAGE TEST

Variable	Time in Months			
	0	6	12	18
Maximum -				
Duration of Test (secs)	180	-	510	-
Heart rate (beats/min)	136	-	148	-
Systolic pressure (mmHg)	-	-	180	-
Pressure x Rate product (/100)	-	-	247	-
ST-segment depression (mV)	1.2	-	1.4	-
VO ₂ (L/min)	.988	-	1.620	-
VO ₂ /wt. (ml/kg/min)	14.39	-	22.84	-
Pulse oxygen (ccO ₂ /kg/beat) ...	.1013	-	.1667	-
R. Q.	-	-	-	-
Submaximum - Stage I				
Heart rate - (beats/min)	142	-	107	-
Systolic Pressure (mm Hg)	-	-	178	-
Pressure x Rate product (/100)	-	-	187	-
ST-segment depression (mV)	1.2	-	.1	-
VO ₂ (L/min)	.988	-	.705	-
VO ₂ /wt. (ml/kg/min)	14.39	-	10.10	-
Pulse oxygen (ccO ₂ /kg/beat) ..	.1013	-	.0943	-
R. Q.	-	-	-	-

DAILY TRAINING

	Time in Months			
	0	6	12	18
<u>BICYCLE ERGOMETER</u>				
Load (kpm/min)	300	375	450	525
Heart rate (beats/min)	120	123	120	112
Systolic pressure (mmHg)	140	145	145	140
Pressure x Rate (/100)	168	178	174	157
<u>TREAD MILL</u>				
Speed (mph)	2.6	3.6	4.0	4.2
Elevation (%)	0	0	2	2
Heart rate (beats/min)	120	120	124	107
Systolic Pressure (mmHg)	105	136	170	160
Pressure x Rate (/100)	126	163	213	171
Plasma Cholesterol (mg%)	273	308	338	-
Plasma Triglycerides (mg%)	175	154	132	-

Subjective evaluation of change in ST-HR relationship:

SUBJECT.....S. G.....1909.....164-173.....88
 BIRTH DATE.....WEIGHT(range).....

MULTISTAGE TEST

Variable	Time in Months			
	0	6	12	18
Maximum -				
Duration of Test (secs).....	420	-	480	-
Heart rate (beats/min).....	125	-	134	-
Systolic pressure (mmHg).....	-	-	144	-
Pressure x Rate product (/100)	-	-	190	-
ST-segment depression (mV)....	1.7	-	1.2	-
VO ₂ (L/min).....	1.482	-	1.740	-
VO ₂ /wt. (ml/kg/min).....	19.96	-	22.17	-
Pulse oxygen (ccO ₂ /kg/beat)...	.1596	-	.1702	-
R. Q.	-	-	1.01	-
Submaximum - Stage I				
Heart rate - (beats/min).....	103	-	97	-
Systolic Pressure (mm Hg).....	-	-	140	-
Pressure x Rate product (/100)	-	-	136	-
ST-segment depression (mV)....	.8	-	0	-
VO ₂ (L/min).....	1.050	-	1.030	-
VO ₂ /wt. (ml/kg/min).....	14.08	-	13.19	-
Pulse oxygen (ccO ₂ /kg/beat)...	.1366	-	.1359	-
R. Q.	-	-	.72	-

DAILY TRAINING

	Time in Months			
	0	6	12	18
<u>BICYCLE ERGOMETER</u>				
Load (kpm/min)	450	450	600	750
Heart rate (beats/min).....	113	110	113	131
Systolic pressure (mmHg).....	130	120	120	125
Pressure x Rate (/100).....	147	132	136	164
<u>TREAD MILL</u>				
Speed (mph).....	3.0	3.8	3.8	4.0
Elevation (%)	0	0	4	4
Heart rate (beats/min).....	107	110	113	126
Systolic Pressure (mmHg).....	130	115	113	105
Pressure x Rate (/100).....	139	127	128	132
Plasma Cholesterol (mg%)	142	160	153	-
Plasma Triglycerides (mg%).....	-	150	150	-

Subjective evaluation of change in ST-HR relationship:

SUBJECT A. P. BIRTH DATE 1929 WEIGHT(range) 144-145

MULTISTAGE TEST

Variable	Time in Months			
	0	6	12	18
Maximum -				
Duration of Test (secs).....	364	435	480	-
Heart rate (beats/min).....	129	124	134	-
Systolic pressure (mmHg).....	-	135	140	-
Pressure x Rate product (/100)	-	173	181	-
ST-segment depression (mV)....	2.4	-	1.4	-
VO ₂ (L/min).....	1.300	1.452	1.720	-
VO ₂ /wt. (ml/kg/min).....	19.90	22.54	26.13	-
Pulse oxygen (ccO ₂ /kg/beat)...	.1580	.1830	.2025	-
R. Q.	-	.90	.87	-
Submaximum - Stage I				
Heart rate - (beats/min).....	101	90	96	-
Systolic Pressure (mm Hg).....	-	125	130	-
Pressure x Rate product (/100)	-	113	129	-
ST-segment depression (mV)....	.3	-	.2	-
VO ₂ (L/min).....	.942	.808	.920	-
VO ₂ /wt. (ml/kg/min).....	14.43	12.54	14.04	-
Pulse oxygen (ccO ₂ /kg/beat)...	.1429	.1393	.1463	-
R. Q.	-	.80	.70	-

DAILY TRAINING

	Time in Months			
	0	6	12	18
<u>BICYCLE ERGOMETER</u>				
Load (kpm/min).....	450	600	750	825
Heart rate (beats/min).....	117	117	120	124
Systolic pressure (mmHg).....	90	95	120	120
Pressure x Rate (/100)	105	111	144	149
<u>TREAD MILL</u>				
Speed (mph).....	3.2	3.6	4.2	4.2
Elevation (%).....	0	5	6	6
Heart rate (beats/min).....	105	115	112	116
Systolic Pressure (mmHg).....	90	95	115	109
Pressure x Rate (/100).....	95	109	129	126
Plasma Cholesterol (mg%)	168	234	239	160
Plasma Triglycerides (mg%).....	-	60	47	80

Subjective evaluation of change in ST-HR relationship:

SUBJECTS. M.....1919.....144-147
 BIRTH DATEWEIGHT(range).....

MULTISTAGE TEST

Variable	Time in Months			
	0	6	12	18
Maximum -				
Duration of Test (secs).....	360	550	585	-
Heart rate (beats/min).....	149	155	173	-
Systolic pressure (mmHg).....	-	125	140	-
Pressure x Rate product (/100)	-	176	242	-
ST-segment depression (mV)....	2.0	-	1.5	-
VO ₂ (L/min).....	-	1.500	1.500	-
VO ₂ /wt. (ml/kg/min).....	-	22.72	22.96	-
Pulse oxygen (ccO ₂ /kg/beat)...	-	.1470	.1327	-
R. Q.	-	1.20	1.21	-
Submaximum - <u>Stage I</u>				
Heart rate - (beats/min).....	113	106	105	-
Systolic Pressure (mm Hg).....	-	115	140	-
Pressure x Rate product (/100)	-	122	147	-
ST-segment depression (mV)....	0	-	0	-
VO ₂ (L/min)	-	1.138	1.830	-
VO ₂ /wt. (ml/kg/min).....	-	17.20	12.65	-
Pulse oxygen (ccO ₂ /kg/beat)...	-	.1620	.1193	-
R. Q.	-	.82	.77	-

DAILY TRAINING

	Time in Months			
	0	6	12	18
<u>BICYCLE ERGOMETER</u>				
Load (kpm/min).....	450	525	750	750
Heart rate (beats/min).....	113	122	130	127
Systolic pressure (mmHg).....	120	105	120	125
Pressure x Rate (/100)	136	128	156	159
<u>TREAD MILL</u>				
Speed (mph).....	3.5	3.5	3.9	4.2
Elevation (%).....	0	5	6	6
Heart rate (beats/min).....	110	117	122	123
Systolic Pressure (mmHg).....	127	110	120	125
Pressure x Rate (/100).....	140	129	146	159
Plasma Cholesterol (mg%)	251	210	-	-
Plasma Triglycerides (mg%)	106	70	-	-

Subjective evaluation of change in ST-HR relationship:

SUBJECT: D. T. 1931 163-180
 BIRTH DATE WEIGHT(range).....

MULTISTAGE TEST

Variable	Time in Months			
	0	6	12	18
Maximum -				
Duration of Test (secs).....	345	450	-	-
Heart rate (beats/min).....	164	164	-	-
Systolic pressure (mmHg).....	140	180	-	-
Pressure x Rate product (/100)	298	298	-	-
ST-segment depression (mV)...	1.0	1.0	-	-
VO ₂ (L/min)	1.705	1.698	-	-
VO ₂ /wt. (ml/kg/min).....	20.87	22.20	-	-
Pulse oxygen (ccO ₂ /kg/beat).. R. Q.	.1296 -	.1353 1.07	- -	- -
Submaximum - Stage I				
Heart rate - (beats/min).....	132	129	-	-
Systolic Pressure (mmHg)	180	180	-	-
Pressure x Rate product (/100)	237	231	-	-
ST-segment depression (mV)...	.2	.1	-	-
VO ₂ (L/min)	1.025	-	-	-
VO ₂ /wt. (ml/kg/min).....	12.55	-	-	-
Pulse oxygen (ccO ₂ /kg/beat).. R. Q.	.0950 -	- -	- -	- -

DAILY TRAINING

	Time in Months			
	0	6	12	18
<u>BICYCLE ERGOMETER</u>				
Load (kpm/min).....	300	375	450	-
Heart rate (beats/min).....	105	126	120	-
Systolic pressure (mmHg).....	135	140	142	-
Pressure x Rate (/100).....	140	176	171	-
<u>TREAD MILL</u>				
Speed (mph)	3.2	3.7	3.8	-
Elevation (%)	0	1	4	-
Heart rate (beats/min).....	125	123	130	-
Systolic Pressure (mmHg).....	125	155	137	-
Pressure x Rate (/100).....	156	196	178	-
Plasma Cholesterol (mg%).....	258	-	274	-
Plasma Triglycerides (mg%).....	300	-	181	-

Subjective evaluation of change in ST-HR relationship:

SUBJECT. L. F. 1918 170-173
 BIRTH DATE.....WEIGHT(range)

MULTISTAGE TEST

Variable	Time in Months			
	0	6	12	18
Maximum -				
Duration of Test (secs)	310	440	455	-
Heart rate (beats/min)	150	144	164	-
Systolic pressure (mmHg)	200	200	200	-
Pressure x Rate product (/100)	300	288	328	-
ST-segment depression (mV).....	-	-	-	-
VO ₂ (L/min)	1.328	1.738	1.309	-
VO ₂ /wt. (ml/kg/min)	17.09	22.54	16.87	-
Pulse oxygen (ccO ₂ /kg/beat)....	.1139	.1513	.1028	-
R. Q.	-	0.93	1.13	-
Submaximum - Stage I				
Heart rate - (beats/min)	125	114	133	-
Systolic Pressure (mm Hg)	-	190	180	-
Pressure x Rate product (/100).	-	217	239	-
ST-segment depression (mV).....	-	-	-	-
VO ₂ (L/min)	-	.740	.930	-
VO ₂ /wt. (ml/kg/min).....	-	9.59	11.95	-
Pulse oxygen (ccO ₂ /kg/beat)....	-	.0841	.0898	-
R. Q.	-	0.67	0.97	-

DAILY TRAINING

	Time in Months			
	0	6	12	18
<u>BICYCLE ERGOMETER</u>				
Load (kpm/min)	300	450	600	750
Heart rate (beats/min)	107	120	124	130
Systolic pressure (mmHg).....	160	145	135	145
Pressure x Rate (/100)	171	174	167	189
<u>TREAD MILL</u>				
Speed (mph)	3.2	3.6	4.0	4.2
Elevation (%)	0	2	2	4
Heart rate (beats/min)	111	120	124	130
Systolic Pressure (mmHg).....	160	160	140	145
Pressure x Rate (/100)	178	192	174	189
Plasma Cholesterol (mg%)	325	233	274	-
Plasma Triglycerides (mg%)	-	164	172	-

Subjective evaluation of change in ST-HR relationship:

Data insufficient

E. W.

1928

148-150

SUBJECT:.....BIRTH DATE.....WEIGHT (range).....

MULTISTAGE TEST

Variable	Time in Months			
	0	6	12	18
Maximum -				
Duration of Test (secs).....	480	6	600	-
Heart rate (beats/min).....	148	-	148	-
Systolic pressure (mm Hg).....	160	-	140	-
Pressure x Rate product (/100)	256	-	203	-
ST-segment depression (mV)....	3.2	-	1.8	-
VO ₂ (L/min)	1.910	-	1.910	-
VO ₂ /wt. (ml/kg/min).....	28.05	-	28.48	-
Pulse oxygen (ccO ₂ /kg/beat)...	.1934	-	.1991	-
R. Q.	.97	-	.96	-
Submaximum - <u>Stage I</u>				
Heart rate - (beats/min).....	117	-	83	-
Systolic Pressure (mm Hg).....	195	-	120	-
Pressure x Rate product (/100)	170	-	99	-
ST-segment depression (mV)....	0.7	-	0.1	-
VO ₂ (L/min).....	1.190	-	1.210	-
VO ₂ /wt. (ml/kg/min).....	17.63	-	17.96	-
Pulse oxygen (ccO ₂ /kg/beat)...	.1506	-	.2163	-
R. Q.	.88	-	.77	-

DAILY TRAINING

	Time in Months			
	0	6	12	18
<u>BICYCLE ERGOMETER</u>				
Load (kpm/min)	375	450	600	-
Heart rate (beats/min).....	100	117	125	-
Systolic pressure (mm Hg).....	110	110	120	-
Pressure x Rate (/100)	110	126	150	-
<u>TREAD MILL</u>				
Speed (mph).....	3.4	4.3	4.8	-
Elevation (%)	0	6	6	-
Heart rate (beats/min)	88	107	108	-
Systolic Pressure (mm Hg).....	100	115	120	-
Pressure x Rate (/100)	88	123	130	-
Plasma Cholesterol (mg%)	203	232	-	-
Plasma Triglycerides (mg%)	153	82	-	-

Subjective evaluation of change in ST-HR relationship:

J. G. 1912 144-149
 SUBJECT:BIRTH DATE.....WEIGHT(range).....

MULTISTAGE TEST

Variable	Time in Months			
	0	6	12	18
Maximum -				
Duration of Test (secs).....	300	360	-	-
Heart rate (beats/min).....	132	141	-	-
Systolic pressure (mm Hg).....	-	125	-	-
Pressure x Rate product (/100).	-	175	-	-
ST-segment depression (mV).....	-	-	-	-
VO ₂ (L/min)	1.233	1.150	-	-
VO ₂ /wt. (ml/kg/min)	18.20	17.71	-	-
Pulse oxygen (ccO ₂ /kg/beat) ...	.1555	.1365	-	-
R. Q.	-	-	-	-
Submaximum - <u>Stage I</u>				
Heart rate - (beats/min).....	110	122	-	-
Systolic Pressure (mm Hg).....	-	125	-	-
Pressure x Rate product (/100)	-	153	-	-
ST-segment depression (mV).....	-	-	-	-
VO ₂ (L/min)	1.100	0.970	-	-
VO ₂ /wt. (ml/kg/min).....	16.00	14.87	-	-
Pulse oxygen (ccO ₂ /kg/beat)....	.1450	.1221	-	-
R. Q.	-	0.88	-	-

DAILY TRAINING

	Time in Months			
	0	6	12	18
<u>BICYCLE ERGOMETER</u>				
Load (kpm/min).....	375	450	525	525
Heart rate (beats/min).....	122	125	122	132
Systolic pressure (mm Hg).....	122	105	112	110
Pressure x Rate (/100)	149	131	137	143
<u>TREAD MILL</u>				
Speed (mph).....	3.0	3.6	3.8	3.6
Elevation (%).....	0	0	6	6
Heart rate (beats/min)	105	122	127	126
Systolic Pressure (mm Hg).....	90	105	100	92
Pressure x Rate (/100).....	95	131	127	116
Plasma Cholesterol (mg%)	175	-	175	-
Plasma Triglycerides (mg%)	-	-	64	-

Subjective evaluation of change in ST-HR relationship:

Data insufficient.

A. K. 1923 153-162
 SUBJECT: BIRTH DATE.....WEIGHT(range).....

MULTISTAGE TEST

Variable	Time in Months			
	0	6	12	18
Maximum -				
Duration of Test (secs)	450	-	450	-
Heart rate (beats/min)	153	-	164	-
Systolic pressure (mm Hg)	180	-	230	-
Pressure x Rate product (/100)	229	-	377	-
ST-segment depression (mV)	-	-	-	-
VO ₂ (L/min)	1.257	-	1.700	-
VO ₂ /wt. (ml/kg/min)	18.12	-	23.17	-
Pulse oxygen (ccO ₂ /kg/beat)....	.1427	-	.1412	-
R. Q.	-	-	.94	-
Submaximum - Stage I				
Heart rate - (beats/min)	105	-	101	-
Systolic Pressure (mm Hg).....	140	-	140	-
Pressure x Rate product (/100).	153	-	141	-
ST-segment depression (mV)	-	-	-	-
VO ₂ (L/min)	.872	-	.930	-
VO ₂ /wt. (ml/kg/min).....	12.57	-	12.70	-
Pulse oxygen (ccO ₂ /kg/beat)....	.1197	-	.1257	-
R. Q.	.99	-	.72	-

DAILY TRAINING

	Time in Months			
	0	6	12	18
<u>BICYCLE ERGOMETER</u>				
Load (kpm/min)	375	450	600	-
Heart rate (beats/min)	127	117	130	-
Systolic pressure (mm Hg).....	140	150	160	-
Pressure x Rate (/100)	178	176	203	-
<u>TREAD MILL</u>				
Speed (mph)	3.0	3.6	4.0	-
Elevation (%)	0	0	2	-
Heart rate (beats/min)	105	115	117	-
Systolic Pressure (mm Hg)	130	140	145	-
Pressure x Rate (/100)	136	161	169	-
Plasma Cholesterol (mg%)	294	254	251	-
Plasma Triglycerides (mg%)	106	113	83	-

Subjective evaluation of change in ST-HR relationship:

Data insufficient.

1925 96

SUBJECT.....V.....D:.....BIRTH DATEWEIGHT(range).....150-154.....

MULTISTAGE TREADMILL TEST

Variable	Time in Months			
	<u>0</u>	<u>6</u>	<u>12</u>	<u>18</u>
Maximum -				
Duration of Test (secs)				
Heart rate (beats/min)				
Systolic pressure (mmHg).....				
Pressure x Rate product (/100)				
ST-segment depression (mV)....				
VO ₂ (L/min)				
VO ₂ /wt. (ml/kg/min)				
Pulse oxygen (ccO ₂ /kg/beat)...				
R. Q.				

B I C Y C L E

E R G O M E T E R

U S E D

Submaximum - Stage I

Heart rate - (beats/min).....

Systolic Pressure (mm Hg).....

Pressure x Rate product (/100)

ST-segment depression (mV)....

VO₂ (L/min)

VO₂ /wt. (ml/kg/min)

Pulse oxygen (ccO₂/kg/beat)...

R. Q.

DAILY TRAINING

	Time in Months			
	<u>0</u>	<u>6</u>	<u>12</u>	<u>18</u>
<u>BICYCLE ERGOMETER</u>				
Load (kpm/min)	300	525	600	-
Heart rate (beats/min)	103	120	118	-
Systolic pressure (mmHg).....	110	128	125	-
Pressure x Rate (/100)	113	154	148	-
<u>TREAD MILL</u>				
Speed (mph)	3.0	3.9	3.8	-
Elevation (%)	0	0	5	-
Heart rate (beats/min)	103	115	118	-
Systolic Pressure (mmHg)	115	128	145	-
Pressure x Rate (/100)	118	147	171	-
Plasma Cholesterol (mg%)	-	219	-	-
Plasma Triglycerides (mg%)	-	232	-	-

Subjective evaluation of change in ST-HR relationship:

6

Coronary angiogram pre and post were performed.

1920

172-180

SUBJECT ...W...R.....BIRTH DATE..... WEIGHT(range).....

MULTISTAGE TEST

Variable	Time in Months			
	<u>0</u>	<u>6</u>	<u>12</u>	<u>18</u>
Maximum -				
Duration of Test (secs).....				
Heart rate (beats/min).....				
Systolic pressure (mmHg).....				
Pressure x Rate product (/100)				
ST-segment depression (mV)....				
VO ₂ (L/min).....				
VO ₂ /wt. (ml/kg/min).....				
R. Q.				
	D A T A			
	U N A V A I L A B L E			
Submaximum - <u>Stage I</u>				
Heart rate - (beats/min).....	115	98	-	-
Systolic Pressure (mm Hg).....	170	170	-	-
Pressure x Rate product (/100)	196	167	-	-
ST-segment depression (mV)....	-	-	-	-
VO ₂ (L/min).....	1.129	1.210	-	-
VO ₂ /wt. (ml/kg/min).....	13.89	15.50	-	-
Pulse oxygen (ccO ₂ /kg/beat)...	.1207	.1581	-	-
R. Q.	-	-	-	-

DAILY TRAINING

	Time in Months			
	<u>0</u>	<u>6</u>	<u>12</u>	<u>18</u>
BICYCLE ERGOMETER				
Load (kpm/min).....	525	750	750	750
Heart rate (beats/min).....	110	110	97	107
Systolic pressure (mmHg).....	110	120	130	135
Pressure x Rate (/100)	121	132	126	146
TREAD MILL				
Speed (mph).....	3.2	3.8	4.0	4.2
Elevation (%)	0	8	6	4
Heart rate (beats/min)	89	100	90	90
Systolic Pressure (mmHg).....	105	115	120	116
Pressure x Rate (/100)	93	115	108	104
Plasma Cholesterol (mg%)	230	266	235	-
Plasma Triglycerides (mg%)	-	132	127	-

Subjective evaluation of change in ST-HR relationship:

- 1

P. P. 1915 160-161
 SUBJECT:.....BIRTH DATE.....WEIGHT(range).....

MULTISTAGE TEST

Variable	Time in Months			
	<u>0</u>	<u>6</u>	<u>12</u>	<u>18</u>
Maximum -				
Duration of Test (secs)				
Heart rate (beats/min)				
Systolic pressure (mmHg).....				
Pressure x Rate product (/100)				
ST-segment depression (mV).....				
VO ₂ (L/min).....				
VO ₂ /wt. (ml/kg/min).....				
Pulse oxygen (ccO ₂ /kg/beat)....				
R. Q.				

D A T A

Submaximum - Stage I

Heart rate - (beats/min).....
 Systolic Pressure (mm Hg).....
 Pressure x Rate product (/100).
 ST-segment depression (mV).....
 VO₂ (L/min).....
 VO₂ /wt. (ml/kg/min).....
 Pulse oxygen (ccO₂/kg/beat)....
 R. Q.

U N A V A I L A B L E

DAILY TRAINING

	Time in Months			
	<u>0</u>	<u>6</u>	<u>12</u>	<u>18</u>
<u>BICYCLE ERGOMETER</u>				
Load (kpm/min)	325	450	525	525
Heart rate (beats/min).....	115	115	110	120
Systolic pressure (mmHg).....	150	150	140	160
Pressure x Rate (/100).....	174	174	165	192
<u>TREAD MILL</u>				
Speed (mph)	3.2	3.7	3.8	3.9
Elevation (%).....	0	0	2	2
Heart rate (beats/min)	115	115	118	120
Systolic Pressure (mmHg).....	135	150	120	150
Pressure x Rate (/100).....	155	174	142	180
Plasma Cholesterol (mg%).....	276	276	268	237
Plasma Triglycerides (mg%)	230	182	204	147

Suggestive evaluation of change in ST-HR relationship:

6

Coronary angiograms pre and post were performed.

C. R. 1922 191 - 195
 SUBJECT: BIRTH DATE WEIGHT(range).....

MULTISTAGE TEST

Variable	Time in Months			
	<u>0</u>	<u>6</u>	<u>12</u>	<u>18</u>
Maximum -				
Duration of Test (secs).....				
Heart rate (beats/min).....				
Systolic pressure (mmHg).....				
Pressure x Rate product (/100)				
ST-segment depression (mV)...				
VO ₂ (L/min).....				D A T A
VO ₂ /wt. (ml/kg/min).....				
Pulse oxygen (ccO ₂ /kg/beat).. R. Q.				

Submaximum - Stage I

Heart rate - (beats/min).....				
Systolic Pressure (mmHg).....				
Pressure x Rate product (/100)				U N A V A I L A B L E
ST-segment depression (mV)...				
VO ₂ (L/min).....				
VO ₂ /wt. (ml/kg/min).....				
Pulse oxygen (ccO ₂ /kg/beat).. R. Q.				

DAILY TRAINING

	Time in Months			
	<u>0</u>	<u>6</u>	<u>12</u>	<u>18</u>
<u>BICYCLE ERGOMETER</u>				
Load (kpm/min)	375	450	525	-
Heart rate (beats/min).....	126	120	120	-
Systolic pressure (mmHg).....	130	120	130	-
Pressure x Rate (/100)	164	144	156	-
<u>TREAD MILL</u>				
Speed (mph).....	3.5	3.8	4.2	-
Elevation (%)	0	4	4	-
Heart rate (beats/min)	120	120	117	-
Systolic Pressure (mmHg).....	130	115	120	-
Pressure x Rate (/100).....	156	138	140	-
Plasma Cholesterol (mg%).....	252	242	210	-
Plasma Triglycerides (mg%).....	196	140	82	-

Subjective evaluation of change in ST-HR relationship:

Data insufficient.

SUBJECT: R. R. BIRTH DATE..1930.....WEIGHT(range).....167-170

MULTISTAGE TEST

Variable	Time in Months			
	<u>0</u>	<u>6</u>	<u>12</u>	<u>18</u>
Maximum -				
Duration of Test(secs).....				
Heart rate (beats/min).....				
Systolic Pressure (mmHg).....				
Pressure x Rate product (/100)				
ST-segment depression (mV)...				
VO ₂ (L/min).....				
VO ₂ /wt. (ml/kg/min).....				
Pulse oxygen (ccO ₂ /kg/beat)..<				
R. Q.				

D A T A

SUBmaximum - Stage I

Heart rate - (beats/min).....
 Systolic Pressure (mm Hg).....
 Pressure x Rate product (/100)
 ST-segment depression (mV)....
 VC₂ (L/min)
 VO₂ /wt. (ml/kg/min)
 Pulse oxygen (ccO₂/kg/beat)..
 R. Q.

U N A V A I L A B L E

DAILY TRAINING

	Time in Months			
	<u>0</u>	<u>6</u>	<u>12</u>	<u>18</u>
<u>BICYCLE ERGOMETER</u>				
Load (kpm/min).....	300	450	525	600
Heart rate (beats/min).....	120	125	130	143
Systolic pressure (mmHg).....	110	123	110	120
Pressure x Rate (/100).....	132	154	143	172
<u>TREAD MILL</u>				
Speed (mph).....	20	36	4.0	4.2
Elevation (%).....	0	0	2	4
Heart rate (beats/min)	115	125	138	126
Systolic Pressure (mmHg).....	120	115	100	110
Pressure x Rate (/100).....	138	144	138	139
Plasma Cholesterol (mg%).....	290	282	256	-
Plasma Triglycerides (mg%).....	194	81	165	-

Subjective evaluation of change in ST-HR relationship:

Data insufficient.

RAW DATA
FOR
POST "INFARCTION"
PATIENTS

SUBJECT:G.:J.....BIRTH DATE ..1908.....WEIGHT(range).....160-161.....

MULTISTAGE TEST

Variable	Time in Months			
	0	6	12	18
Maximum -				
Duration of Test (secs).....	455	-	480	-
Heart rate (beats/min).....	164	-	182	-
Systolic pressure (mmHg).....	220	-	180	-
Pressure x Rate product (/100)	360	-	328	-
VO ₂ (L/min).....	1.412	-	1.570	-
VO ₂ /wt. (ml/kg/min).....	19.34	-	20.23	-
Pulse oxygen (ccO ₂ /kg/beat)...	.1179	-	.1124	-
R. Q.	.89	-	1.04	-
Submaximum - Stage I				
Heart rate - (beats/min).....	114	-	135	-
Systolic Pressure (mm Hg).....	220	-	170	-
Pressure x Rate product (/100)	250	-	230	-
VO ₂ (L/min)	.799	-	.910	-
VO ₂ /wt. (ml/kg/min)	10.66	-	11.69	-
Pulse oxygen (ccO ₂ /kg/beat)...	.0936	-	.0866	-
R. Q.	.80	-	.85	-
Submaximum - Stage II				
Heart rate - (beats/min)	143	-	161	-
Systolic Pressure (mm Hg)	220	-	180	-
Pressure x Rate product (/100)	315	-	290	-
VO ₂ (L/min)	1.307	-	1.430	-
VO ₂ /wt. (ml/kg/min)	17.89	-	18.47	-
Pulse oxygen (ccO ₂ /kg/beat)...	.1251	-	.1147	-
R. Q.	.84	-	1.04	-

DAILY TRAINING

	Time in Months			
	0	6	12	18
BICYCLE ERGOMETER				
Load (kpm/min)	150	450	525	675
Heart rate (beats/min).....	110	122	137	145
Systolic pressure (mm Hg)	157	150	140	160
Pressure x Rate (/100)	173	183	192	232
TREAD MILL				
Speed (mph)	2.6	3.4	3.8	4.0
Elevation (%)	0	0	2	2
Heart rate (beats/min)	112	122	133	137
Systolic Pressure (mm Hg)	160	170	170	165
Pressure x Rate (/100)	174	207	226	226
Plasma Cholesterol (mg%)	274	210	283	213
Plasma Triglycerides (mg%)	-	110	77	43

SUBJECT: M. U. BIRTH DATE 1919 WEIGHT(range) 150-154

MULTISTAGE TEST

Variable	Time in Months			
	0	6	12	18
Maximum -				
Duration of Test (secs).....	390	610	635	635
Heart rate (beats/min)	136	161	134	155
Systolic pressure (mmHg)	-	-	235	200
Pressure x Rate product (/100)	-	-	315	310
VO ₂ (L/min)	1.449	1.7611	1.750	2.140
VO ₂ /wt. (ml/kg/min)	21.25	25.9	25.61	30.67
Pulse oxygen (ccO ₂ /kg/beat) ..	.1741	0.1611	0.1911	0.1079
R. Q.	-	-	1.14	1.05
Submaximum - Stage I				
Heart rate - (beats/min)	102	98	85	95
Systolic Pressure (mm Hg)	-	-	-	140
Pressure x Rate product (/100)	-	-	-	133
VO ₂ (L/min)	1.053	0.966	1.091	0.950
VO ₂ /wt. (ml/kg/min)	15.43	14.27	13.39	13.62
Pulse oxygen (ccO ₂ /kg/beat)...	0.1513	0.1446	.1446	.1434
R. Q.	-	-	0.87	0.71
Submaximum - Stage II				
Heart rate - (beats/min)	122	115	101	100
Systolic Pressure (mm Hg)	-	-	170	100
Pressure x Rate product (/100)	-	-	171	160
VO ₂ (L/min)	1.449	1.313	1.212	1.310
VO ₂ /wt. (ml/kg/min).....	21.25	19.26	17.79	18.87
Pulse oxygen (ccO ₂ /kg/min)....	0.1741	0.1674	0.1751	0.1887
R. Q.	-	-	0.95	0.77

DAILY TRAINING

	Time in Months			
	0	6	12	18
BICYCLE ERGOMETER				
Load (kpm/min)	600	675	900	900
Heart rate (beats/min)	115	115	114	110
Systolic pressure (mm Hg).....	160	150	140	150
Pressure x Rate (/100)	184	172	160	165
TREAD MILL				
Speed (mph)	4.0	3.7	4.2	4.2
Elevation (%)	0	5	6	6
Heart rate (beats/min)	125	105	114	110
Systolic Pressure (mm Hg)	160	145	140	130
Pressure x Rate (/100)	200	167	160	143
Plasma Cholesterol (mg%)	240	-	181	-
Plasma Triglycerides (mg%)	160	-	118	-

SUBJECT:H.....N..... BIRTH DATE:1925.....WEIGHT(range).....165-167.....

MULTISTAGE TEST

Variable	Time in Months			
	0	6	12	18
Maximum -				
Duration of Test (secs).....	390	615	675	-
Heart rate (beats/min).....	153	173	176	-
Systolic pressure (mm Hg).....	-	190	164	-
Pressure x Rate product (/100)	-	317	285	-
VO ₂ (L/min)	1.501	2.040	2.400	-
VO ₂ /wt. (ml/kg/min)	20.01	27.36	31.56	-
Pulse oxygen (ccO ₂ /kg/beat)...	0.1599	0.1631	0.1818	-
R. Q.	-	1.24	1.05	-
Submaximum - Stage I				
Heart rate - (beats/min)	101	89	94	-
Systolic Pressure (mm Hg)	-	150	150	-
Pressure x Rate product (/100)	-	134	141	-
VO ₂ (L/min)	.897	.971	1.030	-
VO ₂ /wt. (ml/kg/min)	11.83	12.97	13.50	-
Pulse oxygen (ccO ₂ /kg/beat)...	.1171	.1457	.1436	-
R. Q.	-	.79	.70	-
Submaximum - Stage II				
Heart rate - (beats/min).....	130	122	114	-
Systolic Pressure (mm Hg).....	-	160	160	-
Pressure x Rate product (/100)	-	195	182	-
VO ₂ (L/min)	1.501	1.422	1.480	-
VO ₂ /wt. (ml/kg/min)	20.01	19.00	19.57	-
Pulse oxygen (ccO ₂ /kg/beat)...	0.1599	0.1557	0.1714	-
R. Q.	-	0.91	0.76	-

DAILY TRAINING

	Time in Months			
	0	6	12	18
BICYCLE ERGOMETER				
Load (kpm/min)	525	600	750	825
Heart rate (beats/min).....	115	122	130	127
Systolic pressure (mm Hg)	130	130	130	130
Pressure x Rate (/100)	149	159	169	152
TREAD MILL				
Speed (mph).....	4.0	3.5	4.0	4.4
Elevation (%)	0	7	5	6
Heart rate (beats/min)	115	122	130	127
Systolic Pressure (mm Hg)	130	130	130	120
Pressure x Rate (/100)	150	159	169	152
Plasma Cholesterol (mg%)	165	-	214	-
Plasma Triglycerides (mg%)	164	-	88	-

SUBJECT: ...D..D:..... BIRTH DATE: ..1923.....WEIGHT(range).173-174.....

MULTISTAGE TEST

Variable	Time in Months			
	<u>0</u>	<u>6</u>	<u>12</u>	<u>18</u>
Maximum -				
Duration of Test (secs).....	360	420	615	585
Heart rate (beats/min).....	150	130	173	167
Systolic pressure (mm Hg).....	152	179	180	180
Pressure x Rate product (/100)	228	232	329	301
VO ₂ (L/min)	1.51	1.624	2.15	2.08
VO ₂ /wt. (ml/kg/min).....	19.12	20.54	27.2	26.08
Pulse oxygen (ccO ₂ /kg/beat)...	.128	.1592	0.157	0.156
R. Q.	-	-	1.05	0.99

Submaximum - Stage I

Heart rate - (beats/min).....	
Systolic Pressure (mm Hg).....	
Pressure x Rate product (/100)	
VO ₂ (L/min).....	
VO ₂ /wt. (ml/kg/min).....	
Pulse oxygen (ccO ₂ /kg/beat)...	
R. Q.	

D A T A

U N A V A I L A B L E

Submaximum - Stage II

Heart rate - (beats/min).....	150	130	143	144
Systolic Pressure (mm Hg).....	152	179	180	148
Pressure x rate product (/100)	228	232	257	213
VO ₂ (L/min)	1.512	1.624	1.659	1.790
VO ₂ /wt. (ml/kg/min)	19.12	20.54	21.03	22.40
Pulse oxygen (ccO ₂ /kg/beat)...	.1275	.1592	.1471	.1555
R. Q.	-	-	.83	.83

DAILY TRAINING

	Time in Months			
	<u>0</u>	<u>6</u>	<u>12</u>	<u>18</u>
<u>BICYCLE ERGOMETER</u>				
Load (kpm/min)	525	675	825	825
Heart rate (beats/min)	123	125	136	145
Systolic pressure (mm Hg)	125	130	140	130
Pressure x rate (/100)	154	163	191	189
<u>TREAD MILL</u>				
Speed (mph)	3.8	3.8	4.0	4.0
Elevation (%)	0	4	4	6
Heart rate (beats/min)	122	130	135	132
Systolic Pressure (mm Hg)	125	130	130	130
Pressure x Rate (/100)	152	169	176	172
Plasma Cholesterol (mg%)	120	-	222	-
Plasma Triglycerides (mg%)	124	-	91	-

P.B. 1921 147-148
 SUBJECT: BIRTH DATE: WEIGHT(range).....

MULTISTAGE TEST

Variable	Time in Months			
	0	6	12	18
Maximum -				
Duration of Test (secs).....	555	600	755	780
Heart rate (beats/min)	164	156	161	161
Systolic pressure (mm Hg).....	-	145	145	145
Pressure x Rate product (/100)	-	229	238	238
VO ₂ (L/min).....	1.952	1.639	1.810	1.970
VO ₂ /wt. (ml/kg/min).....	28.82	24.63	27.98	29.36
Pulse oxygen (ccO ₂ /kg/beat)...	.1779	.1578	.1826	.1823
R. Q.	-	-	1.13	.99
Submaximum - Stage I				
Heart rate - (beats/min)	101	110	91	97
Systolic Pressure (mm Hg)	-	122	120	140
Pressure x Rate product (/100)	-	133	109	136
VO ₂ (L/min)	.822	.810	.660	.800
VO ₂ /wt. (ml/kg/min)	12.30	12.00	.908	11.87
Pulse oxygen (ccO ₂ /kg/beat)...	.1226	.1098	.1000	.1223
R. Q.	-	-	.90	.78
Submaximum - Stage II				
Heart rate - (beats/min).....	119	122	105	105
Systolic Pressure (mm Hg)	-	130	115	140
Pressure x Rate product (/100)	-	157	121	147
VO ₂ (L/min)	1.312	1.156	.830	1.020
VO ₂ /wt. (ml/kg/min).....	19.38	17.42	12.49	14.05
Pulse Oxygen (ccO ₂ /kg/beat)...	.1628	.1427	.1200	.1370
R. Q.	-	-	.90	.79

DAILY TRAINING

	Time in Months			
	0	6	12	18
<u>BICYCLE ERGOMETER</u>				
Load (kpm/min)	675	750	750	900
Heart rate (beats/min)	110	117	122	122
Systolic pressure (mm Hg).....	120	102	110	125
Pressure x Rate (/100)	132	119	134	153
<u>TREAD MILL</u>				
Speed (mph)	4.2	3.7	4.4	4.8
Elevation (%)	0	5	10	8
Heart rate (beats/min)	110	105	120	122
Systolic Pressure (mm Hg).....	125	92	110	120
Pressure x Rate (/100)	138	103	132	148
Plasma Cholesterol (mg%).....	130	245	252	-
Plasma Triglycerides (mg%)	100	109	119	-

S. P. 1911 132-133
 SUBJECT: BIRTH DATE WEIGHT(range).....

MULTISTAGE TEST

Variable	Time in Months			
	0	6	12	18
Maximum -				
Duration of Test (secs)	485	630	630	-
Heart rate (beats/min)	127	127	138	-
Systolic pressure (mm Hg).....	-	200	152	-
Pressure x Rate product (/100)	-	254	210	-
VO ₂ (L/min).....	1.468	1.530	1.520	-
VO ₂ /wt. (ml/kg/min)	24.28	25.57	25.20	-
Pulse oxygen (ccO ₂ /kg/beat)...	.2151	.2013	.1856	-
R. Q.	-	1.05	1.03	-
Submaximum - Stage I				
Heart rate - (beats/min)	97	95	92	-
Systolic Pressure (mm Hg)	-	165	130	-
Pressure x Rate product (/100)	-	155	120	-
VO ₂ (L/min)	-	.890	0.910	-
VO ₂ /wt. (ml/kg/min)	-	14.80	15.18	-
Pulse oxygen (ccO ₂ /kg/beat)...	-	.1520	.1639	-
R. Q.	-	.89	.75	-
Submaximum - Stage II				
Heart rate - (beats/min).....	100	108	105	-
Systolic Pressure (mm Hg).....	-	155	135	-
Pressure x Rate product (/100)	-	167	142	-
VO ₂ (L/min)	1.300	1.270	1.160	-
VO ₂ /wt. (ml/kg/min)	21.51	21.23	19.31	-
Pulse oxygen (ccO ₂ /kg/beat)...	.2151	.1975	0.1840	-
R. Q.	-	.92	.82	-

DAILY TRAINING

	Time in Months			
	0	6	12	18
BICYCLE ERGOMETER				
Load (kpm/min)	525	675	750	750
Heart rate (beats/min).....	120	112	117	117
Systolic pressure (mm Hg)	144	140	140	140
Pressure x Rate (/100)	173	164	164	164
TREAD MILL				
Speed (mph)	4.0	3.7	4.2	4.4
Elevation (%)	0	6	8	6
Heart rate (beats/min)	110	104	108	105
Systolic Pressure (mm Hg).....	110	110	132	135
Pressure x Rate (/100)	121	114	143	142
Plasma Cholesterol (mg%).....	318	-	316	238
Plasma Triglycerides (mg%).....	105	-	73	63

W. P. 1919 175-182
 SUBJECT:BIRHT DATE:WEICHT(range).....

MULTISTAGE TEST

Variable	Time in Months			
	0	6	12	18
Maximum -				
Duration of Test (secs)	450	450	720	780
Heart rate (beats/min)	164	145	164	160
Systolic pressure (mm Hg).....	-	170	155	158
Pressure x Rate product (/100)	-	247	254	253
VO ₂ (L/min)	2.07	1.97	2.94	3.06
VO ₂ /wt. (ml/kg/min).....	25.0	24.3	37.0	37.5
Pulse oxygen (ccO ₂ /kg/beat)...	0.152	0.167	0.226	0.234
R. Q.	-	-	1.20	1.09

Submaximum - Stage I

Heart rate - (beats/min)

Systolic Pressure (mm Hg).....

Pressure x Rate product (/100)

VO₂ (L/min)

VO₂ /wt. (ml/kg/min)

Pulse oxygen (ccO₂/kg/beat)...

R. Q.

D A T A

U N A V A I L A B L E

Submaximum - Stage II

Heart rate (beats/min)

Systolic Pressure (mm Hg)

Pressure x Rate product (/100)

VO₂ (L/min).....

VO₂ /wt. (ml/kg/min)

Pulse oxygen (ccO₂/kg/beat) ..

R. Q.

DAILY TRAINING

	Time in Months			
	0	6	12	18
<u>BICYCLE ERGOMETER</u>				
Load (kpm/min)	450	675	900	900
Heart rate (beats/min)	123	120	118	120
Systolic pressure (mm Hg).....	110	110	120	110
Pressure x Rate (/100)	135	132	142	132
<u>TREAD MILL</u>				
Speed (mph)	3.4	3.8	4.2	4.6
Elevation (%)	0	5	6	6
Heart rate (beats/min)	122	115	125	118
Systolic Pressure (mm Hg).....	119	100	125	120
Pressure x Rate (/100)	145	115	156	142
Plasma Cholesterol (mg%)	219	-	226	-
Plasma Triglycerides (mg%).....	75	-	100	-

H. H. 1929 186-187
 SUBJECT:BIRTH DATE.....WEIGHT(range).....

MULTISTAGE TEST

Variable	Time in Months			
	<u>0</u>	<u>6</u>	<u>12</u>	<u>18</u>
Maximum -				
Duration of Test (secs).....	630	720	660	-
Heart rate (beats/min).....	173	172	169	-
Systolic pressure (mm Hg).....	200	170	-	-
Pressure x Rate product (/100)	346	292	-	-
VO ₂ (L/min)	2.104	2.622	2.640	-
VO ₂ /wt. (ml/kg/min)	25.23	31.07	31.30	-
Pulse oxygen (ccO ₂ /kg/beat) ..	.1458	.1806	.1842	-
R. Q.	-	1.23	1.00	-
Submaximum - <u>Stage I</u>				
Heart rate - (beats/min).....	113	90	107	-
Systolic Pressure (mm Hg).....	160	175	162	-
Pressure x Rate product (/100)	181	153	173	-
VO ₂ (L/min)	1.366	1.106	.940	-
VO ₂ /wt. (ml/kg/min).....	16.11	13.11	11.12	-
Pulse oxygen (ccO ₂ /kg/beat)...	.1426	.1457	.1044	-
R. Q.	-	.70	.78	-
Submaximum - <u>Stage II</u>				
Heart rate - (beats/min)	125	108	124	-
Systolic Pressure (mm Hg).....	180	135	120	-
Pressure x Rate product (/100)	225	147	148	-
VO ₂ (L/min)	1.528	1.508	1.470	-
VO ₂ /wt. (ml/kg/min)	18.02	17.87	17.48	-
Pulse oxygen (ccO ₂ /kg/beat)...	.1440	.1639	.1410	-
R. Q.	-	.91	.73	-

DAILY TRAINING

	Time in Months			
	<u>0</u>	<u>6</u>	<u>12</u>	<u>18</u>
<u>BICYCLE ERGOMETER</u>				
Load (kpm/min)	450	525	750	750
Heart rate (beats/min).....	112	116	130	138
Systolic pressure (mm Hg).....	115	120	122	120
Pressure x Rate (/100).....	129	139	154	166
<u>TREAD MILL</u>				
Speed (mph).....	3.4	3.8	4.3	4.6
Elevation (%)	0	2	6	6
Heart rate (beats/min).....	105	120	120	130
Systolic Pressure (mm Hg)	90	115	115	124
Pressure x Rate (/100)	95	138	138	161
Plasma Cholesterol (mg%).....	263	310	267	322
Plasma Triglycerides (mg%)	156	107	105	113

C. R. 1919 155-156
 SUBJECT:.....BIRTH DATE.....WEIGHT(range).....

MULTISTAGE TEST

Variable	Time in Months			
	0	6	12	18
Maximum -				
Duration of Test (secs).....	555	780	-	-
Heart rate (beats/min).....	153	164	-	-
Systolic pressure (mm Hg).....	190	170	-	-
Pressure x Rate product (/100)	291	279	-	-
VO ₂ (L/min)	2.430	3.100	-	-
VO ₂ /wt. (ml/kg/min).....	34.58	43.82	-	-
Pulse oxygen (ccO ₂ /kg/beat)...	.2260	.2671	-	-
R. Q.	1.00	.94	-	-
Submaximum - Stage I				
Heart rate - (beats/min)	110	89	-	-
Systolic Pressure (mm Hg)	155	130	-	-
Pressure x Rate product (/100)	171	116	-	-
VO ₂ (L/min)	1.360	1.130	-	-
VO ₂ /wt. (ml/kg/min)	14.34	15.99	-	-
Pulse oxygen (ccO ₂ /kg/beat)...	.83	.70	-	-
Submaximum - Stage II				
Heart rate - (beats/min)	127	103	-	-
Systolic Pressure (mm Hg).....	173	122	-	-
Pressure x Rate product (/100)	219	126	-	-
VO ₂ (L/min)	1.770	1.530	-	-
VO ₂ /wt. (ml/kg/min).....	25.18	21.64	-	-
Pulse oxygen (ccO ₂ /kg/beat)...	.1982	.2100	-	-
R. Q.	.89	.74	-	-

DAILY TRAINING

	Time in Months			
	0	6	12	18
<u>BICYCLE ERGOMETER</u>				
Load (kpm/min)	825	900	1200	-
Heart rate (beats/min).....	135	120	145	-
Systolic pressure (mm Hg).....	130	110	130	-
Pressure x Rate (/100)	176	132	189	-
<u>TREAD MILL</u>				
Speed (mph)	4.5	4.8	5.0	-
Elevation (%)	0	3	8	-
Heart rate (beats/min).....	132	135	128	-
Systolic Pressure (mm Hg).....	130	130	110	-
Pressure x Rate (/100)	170	176	141	-
Plasma Cholesterol (mg%)	372	259	-	-
Plasma Triglycerides (mg%)	310	413	-	-

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